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# AVIATION MEDICINE

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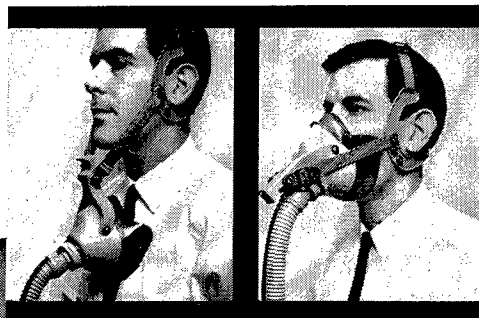
- ♦ Problems in Astroradiobiology
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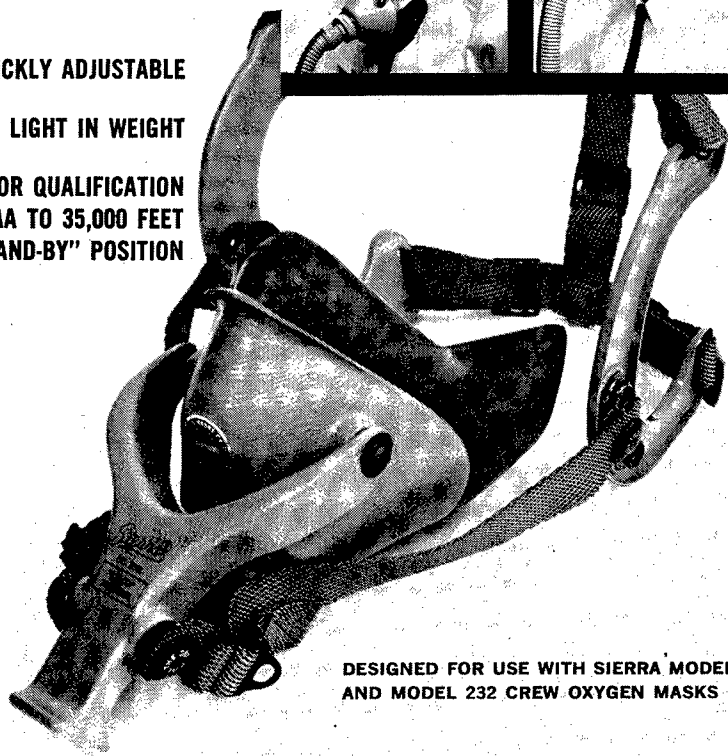
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Formerly THE JOURNAL OF AVIATION MEDICINE

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Director, Aeromedical Laboratory, University of Illinois

Editorial Office: 394 South Kenilworth Avenue, Elmhurst, Illinois

WILLIAM J. KENNARD, M.D., *Managing Editor*

Aerospace Medical Association

Washington National Airport, Washington 1, D. C.

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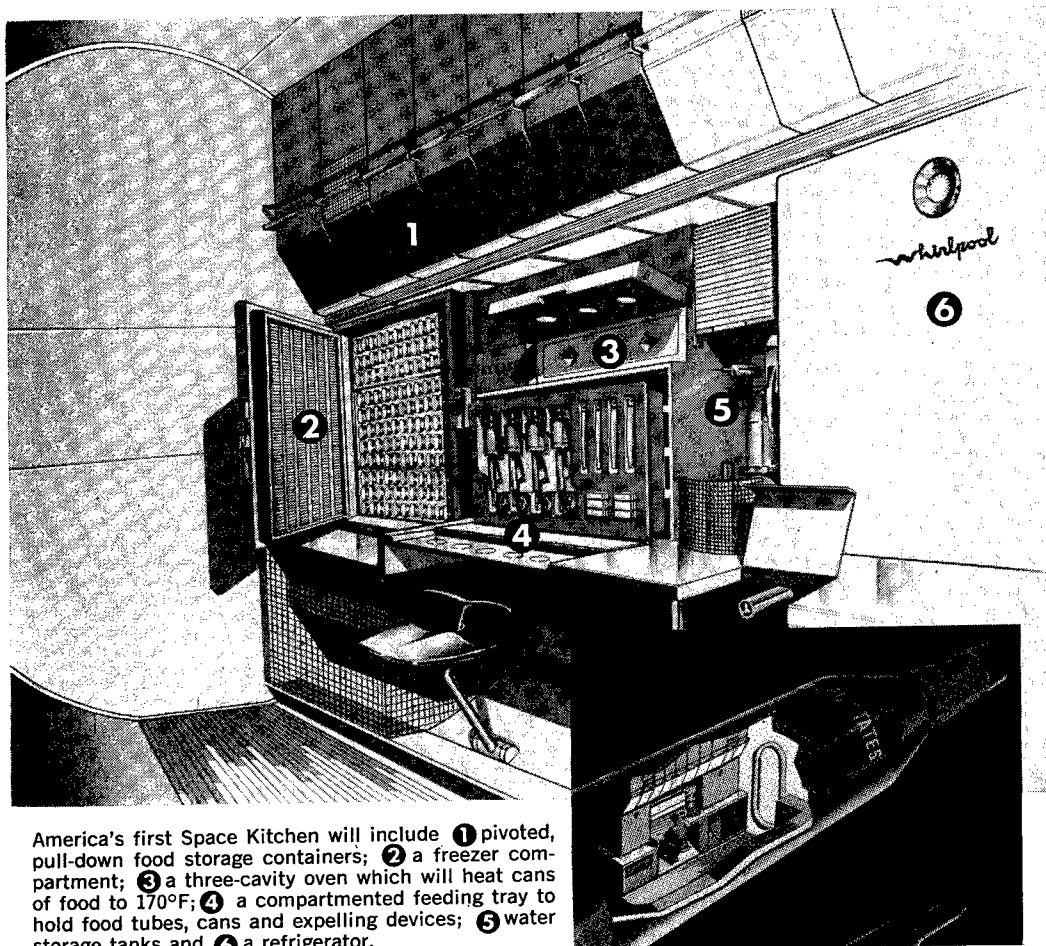
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# AEROSPACE MEDICINE

*Published Monthly by the Aerospace Medical Association*

Devoted to the biologic aspects of flight in the interests of the members of the Aerospace Medical Association and its affiliated societies, Airline Medical Directors Association, Civil Aviation Medical Association, Space Medicine Branch, and Society of Air Force Flight Surgeons

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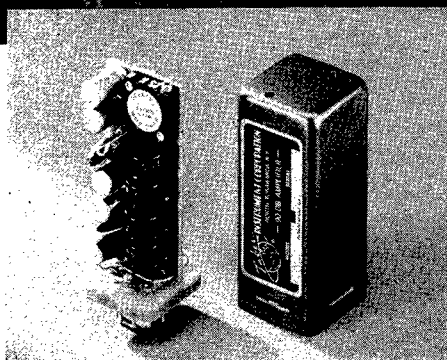
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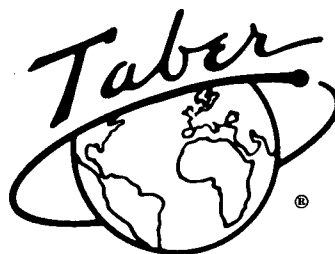
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AEROSPACE INSTRUMENTATION

# AEROSPACE MEDICINE

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## Medical Criteria for Passenger Flying

THE COMMITTEE ON MEDICAL CRITERIA  
OF THE  
AEROSPACE MEDICAL ASSOCIATION

THE ever-increasing number of passengers traveling by air includes a certain proportion who have various types and degrees of clinical disorders. This fact requires that certain medical criteria for passenger flying be established. Passenger air travel has increased 2,600 per cent during the last twenty years. More and more often it is found that flying is the most expeditious and desirable form of transportation of the properly prepared and selected patient. Under certain circumstances flying may be deleterious to the patient and, at times, the transportation of patients by air may be inadvisable so far as it affects fellow passengers. In the

best interests of the public generally and the patient specifically, medical criteria are needed which will improve the proper selection of patients for transportation by air. These criteria should fulfill two main objectives.

1. Clarify, standardize, and establish medical measures which will expedite the transportation by air of properly selected and prepared patients.
2. Establish and clarify certain medical standards by which patients who would compromise the comfort of other passengers or who would be unable to tolerate the ordinary physiologic "stimuli" associated with flying can be disqualified from travel by air.

Once the medical criteria have been set up, the most effective procedures possible for acquainting physicians throughout the country with the criteria and the appropriate application of the criteria should be employed.

There has been considerable military and civilian experience in the transportation of patients by air. The military transportation of patients originated in 1915, and at the time of World War II medical evacuation of patients by air had become routine. Between January 1943, and April 1947, the United States Air Force transported 1,261,933 patients by air and the death rate of patients during flight was only 3.4 per 100,000. Forty-three per cent of those who died were litter patients. Fifty per cent of the patients had clinical conditions unrelated directly to active combat.

Although dealing with a different type of

The Aerospace Medical Association Committee on Medical Criteria for Passenger Flying consists of the following members: C. C. Gullett, M.D., Trans World Airlines, Inc.; J. J. Hutson, M.D., Eastern Airlines; L. R. Krasno, M.D., United Air Lines; Lt. Col. F. S. Spiegel, USAF (MC); K. L. Stratton, M.D., American Airlines, Inc.; J. E. Smith, M.D., Federal Aviation Agency; H. D. Vickers, M.D., Flying Physicians Association; O. B. Schreuder, M.D., Pan American World Airways (Chairman).

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## MEDICAL CRITERIA FOR PASSENGER FLYING

passenger population, the statistics obtained from civilian air lines are equally impressive. The death rate of passengers during flight for the period 1930 through 1951 was 0.6 per 1,000,000 revenue passengers. Seventy-two per cent (fifty-two cases) of deaths were attributed to cardiovascular disease, comprised of twenty instances of myocardial infarctions, six of acute cardiac failures, twenty-one of nonspecific cardiac disease and five of cerebral vascular accidents. Seven deaths were caused by pulmonary disease, such as bronchopneumonia, pneumothorax, asthma, and pulmonary emboli.

An analysis of the frequency of military and civilian deaths in flight readily indicates the minimal degree to which this type of death occurs. This information reveals the relative safety of air transportation and the extent to which it can be used as the most expeditious form of travel for the majority of patients. However, these data also indicate that the patient who has cardiopulmonary disease requires particular consideration in regard to air travel.

### GUIDING PRINCIPLES FOR AIR TRAVEL

#### PATIENT'S ABILITY TO TRAVEL

When a patient is being considered for air travel, a very basic, and what might appear to be an elementary, decision must be established: "Is the patient able to travel, or to be moved by any means?"

This point is sometimes overlooked by the layman and even by the busy practitioner. First, therefore, it must be established from a purely medical or surgical standpoint that the patient can be moved. For instance, a prospective passenger who has a peptic ulcer from which hemorrhage or perforation is imminent should be in the hospital under active treatment, and with emergency medical and surgical facilities readily at hand. Such a condition and others are really indications for hospitalization, and not simply contraindications to travel by air, compared to other means of transportation.

#### CONSIDERATION OF PUBLIC

After the basic decision has been reached that the patient can be transported, it must be de-

termined if air travel is the most desirable for all concerned. It must be remembered that the basic purpose of a common carrier is to transport members of the public, whether it be for pleasure or for business, and that the vehicle is not necessarily to take the place of an ambulance. In other words, the general public must be given consideration and not be subjected to the unpleasant appearances, odors, or sounds of an ill or invalid patient or to the ravings and hazards of a psychotic passenger.

#### STABILITY OF PATIENT'S CONDITION

Another important factor to be considered is the stability of the condition from which the patient suffers. Even though most air liners in flight over the United States are within thirty to forty minutes of emergency landing facilities and modern medical centers, the general public should not be subjected to the inconvenience of nonscheduled landings and interruption of flight schedules. Such untoward incidents also can be very costly to the air line concerned if the landing requires the dumping of thousands of gallons of fuel to permit a landing to be made within the weight limits prescribed for the airplane at a normal landing.

#### HUMAN EMOTIONS

Human emotions sometimes arise insidiously to replace good judgment and sound action. That is, patients fatally ill have been known to express the desire to return to their home or birthplace to die. Another instance concerns the person hopelessly afflicted who is taken on a pilgrimage to some shrine or holy place in the hope that a miraculous cure will be effected. Incidents such as these are pitiful and evoke much sympathy but, nonetheless, very careful evaluation must be made to determine the eligibility of the victims to fly as passengers on commercial air lines, for the reasons just mentioned.

#### EMPIRICAL GUIDE FOR AIR-TRAVEL FITNESS

Many years ago an empirical principle was developed which still has considerable merit and is still valid to a great extent: a person who looks normal, feels normal, smells normal, and

# MEDICAL CRITERIA FOR PASSENGER FLYING

TABLE I—OPERATIONAL FACTORS CONCERNING SIX AIRCRAFT COMMONLY EMPLOYED  
BY AMERICAN CARRIERS

Factor	Aircraft					
	Boeing 707	Douglas DC-8	Lockheed Electra	Vickers Viscount	Douglas DC-7	Convair 240
Speed, cruising (miles per hour)	555	555	405	335	315	245
Speed, take-off (miles per hour)*	190	190	150	130	149	128
Speed, landing (miles per hour)†	155	155	125	136	139	118
Climb, rate (feet per minute), average	1,000	1,000	1,800	900	500	500
Climb, rate (feet per minute), maximal	4,000	4,000	2,200	1,350	2,000	1,000
Descent, rate (feet per minute), average	1,600	1,500	1,500	1,800	1,000	500
Descent, rate (feet per minute), maximal	15,000	15,000	5,000	3,000	6,500	6,000
Range, statute miles	6,100	5,500	3,500	1,400	5,200	1,100
Runway, length needed (feet)‡						
Maximal: take-off	10,500	9,500	4,750	5,440	6,350	4,500
Maximal: landing	6,800	6,700	4,750	4,870	5,100	2,400
Cabin differential pressure, maximal (pounds per square inch)	8.6	8.77	6.5	6.5	5.45	3.5
Capacity, maximal (passengers)	189	189	104	50	99	40
Operating altitude, normal (feet)	25,000	25,000	18,000	16,000	15,000	9,000
	to 40,000	to 40,000	to 25,000	to 25,000	to 25,000	to 12,000
Berths available §	(4)	(4)	None	None	mm (4)	None
Litter patients, accommodations for	(4)	(4)	(4)	(4)	(4)	None

\* With maximal take-off gross weight.

† With maximal landing gross weight.

§ Availability varies among the various airlines.

‡ At sea level and standard temperature 0 C and standard pressure of 29.92 in. of mercury or 760 mm. of mercury.

can walk up the steps of a ramp can fly without likelihood of difficulty. The principle is generally true today, and with the advent of pressurized, high-speed aircraft, it can be expanded somewhat.

## OPERATIONAL CONSIDERATIONS

It is useful and most desirable for the physician who must make a decision as to a patient's travel by air to be aware and to possess some knowledge of certain operational data concerning airplanes. Of particular interest are such factors as the speed and duration of flight, the altitude within the cabin, the availability of oxygen and the ability of the cabin attendants to take care of medical emergencies.

In Table I are some statistics on operational factors of a few of the aircraft currently in use by American carriers.

## PRESSURIZATION OF THE AIRCRAFT

One of the most important factors in the comfort of the passenger, and particularly so

in the transportation of patients by air, is pressurization of the aircraft, since the altitude within the cabin is dependent upon such pressurization. The altitude to which passengers in the cabin are exposed depends upon two factors: first the actual altitude at which the airplane is flying, and second, the cabin altitude produced by pressurization of the aircraft. As the pressurized plane ascends, air taken through the ventilating system is compressed and forced into the cabin under pressure. The system involves the use of mechanical superchargers in one or more stages which continuously impel ambient air into the cabin. In most aircraft the pressure within the cabin is controlled by automatically regulated outlet valves which balance the mass flow of the compressor so as to maintain the necessary pressure differential and cabin ventilation at altitude. To maintain a constant pressure within the cabin in flight; the ratio of compression and the pressure differential across the cabin become functions of altitude. By referring to Tables I and II it

# MEDICAL CRITERIA FOR PASSENGER FLYING

TABLE II.—AMBIENT (ACTUAL) ALTITUDES VERSUS CABIN ALTITUDES IN SIX AIRCRAFT  
COMMONLY USED BY AMERICAN CARRIERS

Ambient Altitude, Feet	Simulated (Cabin) Altitude, Feet, in					
	Boeing 707	Douglas DC-8	Lockheed Electra	Vickers Viscount*	Douglas DC-7	Convair 240
40,000	7,500	7,000				
35,000	5,500	5,000				
30,000	3,700	3,200	8,000			
25,000	1,400	1,000	5,400	7,900	8,000	
22,500	Sea level	Sea level	4,100	6,510	6,500	
20,000			2,650	4,930	5,000	9,700
15,000			Sea level	1,750	1,800	6,000
10,000				Sea level	Sea level	2,000
7,500						200
5,000						Sea level

\*Usually operated at a pressure of 5.5 lb. per square inch.

TABLE III.—ALTITUDE VERSUS ATMOSPHERIC  
PRESSURES

Altitude, Feet	Atmospheric Pressure, Pounds per Square Inch
40,000	2.72
35,000	3.40
25,000	5.46
22,500	6.10
20,000	6.75
15,000	8.30
10,000	10.11
7,500	11.20
5,000	12.20
2,500	13.30
Sea level	14.70

can be seen that in the cabins of the Boeing 707 and the Douglas DC-8, with a pressure differential of 8.6 and 8.77 pounds per square inch (psi), respectively, a sea-level equivalent is maintained at approximately the same actual altitude, namely, 22,500 feet. In addition, in Table II are shown the altitudes in the cabins of some of the currently used aircraft as compared to the ambient altitudes (actual) at which the airplane might be flying.

In actual practice it is easy to calculate the altitude in the cabin if the ambient altitude, the atmospheric pressure at that altitude in pounds per square inch and the pressure differential of the aircraft are known. The altitude in the cabin is determined by adding the pressure differential of the specific aircraft to the atmospheric pressure (in pounds

per square inch). For example, a Boeing 707 with a pressure differential of 8.6 pounds per square inch and flying at an altitude of 22,500 feet at which the atmospheric pressure as shown in Table III is 6.1 pounds per square inch would have approximately a sea-level equivalent.

## OXYGEN FOR PASSENGERS

In the interests of safety during flight, oxygen is available on regularly scheduled aircraft. The requirements are rigid and are in accordance with current United States Government regulations. The requirements depend upon the altitude to which the specific aircraft is allowed to fly by certification. For example, in airplanes certificated to fly at an altitude of more than 25,000 feet, members of the crew are provided with the demand type of oxygen equipment with an oxygen-supply terminal immediately available to each member of the crew, this system being separate from the passenger supply system. Additionally, in airplanes certificated to fly at altitudes of more than 25,000 feet the oxygen supply is available to each passenger through oxygen-supply terminals. Of particular interest is the fact that in all larger aircraft first-aid oxygen equipment is carried in the form of portable oxygen bottles with attached oxygen masks. Government regulations also set forth the rate of oxygen flow that is required under certain conditions. These regulations are strictly complied with by all air carriers.

## MEDICAL CRITERIA FOR PASSENGER FLYING

### EMERGENCY EQUIPMENT

Moreover, in the interest of the safety of the passenger, certain equipment is required for aircraft flying over extended bodies of water. This equipment includes a life vest for each occupant, a sufficient number of life rafts of adequate capacity and buoyancy to accommodate all occupants and certain essential survival and first-aid supplies. Regulations additionally require that certain first-aid equipment be carried by passenger aircraft. As a general rule, the stipulated first-aid supplies are supplemented by other supplies by the individual air carrier.

### TOLERANCE OF SEATS AND SEAT BELTS

There are many other requirements pertaining to the safety of the flying public, one of which concerns the tolerance of the seats and seat belts to stress. The seats and seat belts must be strong enough to withstand the following "g" forces: upward, 2.0 g; forward, 9.0 g; sideward, 1.5 g; and downward, 4.5 g. However, some manufacturers and air lines have cooperated in providing seats with a maximal strength of structure and anchorage within allowable weight limits, producing a seat which can absorb shock caused by sudden deceleration to a degree which is in excess of government requirements.

### TRAINING OF PASSENGER ATTENDANTS

In the interest of comfort and service to the passenger most air lines give much thought and care to the selection and training of cabin attendants. The training period varies according to the individual air line, but in general it consists of an initial course of three to six weeks, and it is followed by a refresher course every six to twelve months. Of particular interest to the medical profession is the fact that the major air lines give the cabin attendants a course in first aid, with supplemental instructions on the "Care of a Normal Delivery." Instruction also is given on subjects such as precautionary sanitary measures aboard the aircraft, and the disinsectization of aircraft to prevent transmission of vectors of disease from one

country to another. Those air lines which use aircraft certificated to fly at altitudes of more than 25,000 feet also give an indoctrination course in the physiologic aspects of flight at high altitudes, with particular emphasis on the use of oxygen and oxygen equipment.

### IMMUNIZATION OF PASSENGERS TRAVELING TO FOREIGN COUNTRIES

International air lines have the responsibility of informing the passenger traveling to certain foreign countries about the immunization requirements of those countries, immunization against certain diseases being not only desirable but occasionally statutory. For example, evidence that vaccination against smallpox has been done within three years of a passenger's proposed admission to a country is required by most countries at the time the passenger presents himself for entry. Full information about immunization requirements can be obtained from the Public Health Service, Division of Foreign Quarantine, United States Department of Health, Education and Welfare, Washington 25, D. C.

Finally, the operational aspects of flying have undergone gradual and steady improvement in the matter of the type of aircraft used by commercial air carriers. Since the advent of turbo-propeller and turbo-jet aircraft with greater speed, decreased vibration and noise and improved pressurization of cabins, flying has become less fatiguing to both members of the crew and passengers.

### PHYSIOLOGIC CONSIDERATIONS

An understanding of the response of the body to the physiologic stimuli exerted by flying is essential to an appropriate evaluation of clinical disturbances as related to transportation by air. Ordinarily, the body which is "physiologically intact" will accommodate adequately the stimuli of flight with little or no difficulty. However, when a disease process has altered normal physiology, considerable discomfort and difficulty may be experienced in adjusting to conditions which are different from the accustomed ones at sea level.

## MEDICAL CRITERIA FOR PASSENGER FLYING

The primary stimulus of air flight which distinguishes it from all other forms of transportation is the change in atmospheric pressure. Many secondary factors characteristic of flying also may be operative at one time or another. These secondary conditions are acceleration, turbulence, vibration and noise. In addition to the factors of flight pertaining to the atmospheric and cabin environment, there is the psychologic aspect of claustrophobia, fear, and apprehension. The subjective factor may, in certain persons, modify the threshold of susceptibility upon which the aforementioned stimuli of flight act and in turn alter the physiologic response to flight.

The following are the conditions associated with flight which should be considered in the light of the physiologic effect they exert on the passenger, particularly in the presence of a clinical disturbance which may impair the normal physiologic response.

### CHANGES IN ATMOSPHERIC PRESSURE

1. *Dysbarism*.—Increased or decreased barometric pressure may disturb normal physiologic function in a number of ways. This type of disturbance is referred to generally as "dysbarism." Certain pre-existing clinical disturbances may predispose the person to dysbarism.

(a) *Barotitis Media*.—This is a traumatic inflammation of the middle ear produced by increased or decreased pressure in that structure in relation to the external environment. The primary cause is failure of proper ventilation of the middle ear during the transition from an environment of relatively low, to one of relatively high, atmospheric pressure, and is encountered most often during the descent of an airplane. Persons who have inflammatory edema of the nasopharyngeal orifice of the eustachian tube are particularly predisposed to this condition.

(b) *Barosinusitis*.—This condition is brought about by inflammation of one or several of the nasal accessory sinuses. As in the case of barotitis media, it is caused by lack of equalization of the pressure of the air within and out-

side the sinus. Generally, the pressure within the sinus is less than the external pressure. Obstruction of the ostia of the sinus by inflamed tissues as a result of the infection of the upper part of the respiratory tract or the presence of a congenital deformity predisposes passengers to barosinusitis.

(c) *Aeroembolism*.—The occurrence of this condition in commercial aviation is not a practical problem. The escape of nitrogen from the blood to an extent at which symptoms will be caused is unlikely to occur at altitudes of less than 25,000 feet. It has been demonstrated that decompressions carried out from 8,000 to 30,000 feet in twelve seconds can be well tolerated by normal persons of essentially all age groups. The major problem, in the event of rapid decompression, is hypoxia. This will be discussed below.

(d) *Aerodontalgia*.—Toothache brought about by decreased barometric pressure at high altitudes seldom occurs in commercial aviation. Nevertheless, persons who have defective fillings, caries and periapical abscess may be particularly predisposed to this discomfort. Occasionally, aerodontalgia may have a basis in pain referred from maxillary arosinusitis.

(e) *Expansion of Gases in Hollow Viscera*.—The expansion of entrapped gases takes place in accordance with Boyle's law, and at an altitude of 5,000 feet such gas will expand 1.2 times and at 10,000 feet, 1.5 times. The clinical significance of this phenomenon will depend on a number of factors such as (1) the particular viscus involved, (2) the physiologic state of this anatomic structure, (3) the quantity of gas present, (4) the degree of reduced atmospheric pressure, (5) the ability of the viscus to expel or to absorb the expanding gas, and (6) the sensitivity or pain threshold of the particular organ involved.

(1) *Gastrointestinal Tract*: The expansion of gases in the gastrointestinal tract under the usual conditions of flight is of no major importance in view of the low simulated altitudes within the cabins. However, when some gastro-



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intestinal pathologic process is involved, expansion of gas to a small degree may give rise to difficulties.

(2) Pulmonary System: The presence of gases within the pleural cavity or mediastinum has the same physical implications as the presence of gases in the gastrointestinal system. Expansion of these gases, regardless of origin, may lead to serious complications as a result of compression of pulmonary tissue and shifting of the mediastinum.

(3) Neurological System: The primary consideration here is the introduction of air into the nervous system for diagnostic purposes, such as for ventriculography and pneumoencephalography. Expansion of gases in these areas may lead to compression of critical centers in the brain.

2. *Hypoxia*.—Decreased barometric pressure at high altitudes reduces alveolar oxygen pressures. Up to an altitude of 10,000 feet this relationship describes almost a straight line. Beyond this altitude, the curve representing alveolar oxygen pressure begins to "flatten" as a result of compensatory increased pulmonary ventilation. A decrease of 50 per cent in the alveolar oxygen pressure is accompanied by a decrease of only 5 per cent in arterial oxygen saturation at an altitude of 10,000 feet. The altitude in the cabins of commercial airplanes usually is about 5,000 to 8,000 feet, depending upon the type of aircraft and the actual altitude, and therefore hypoxia has no practical implication in respect to the normal passenger under everyday flying conditions. However, there are clinical disorders in which the slightest decrement in arterial oxygen saturation can precipitate severe difficulties. Patients in whom cardiopulmonary function or the oxygen transport system is impaired must be carefully selected and prepared for air travel.

### ACCELERATION

Linear acceleration in commercial aviation has not been considered to be a practical problem. Up to the present, linear acceleration in the commercial type of aircraft, particularly

during take-off, when the accelerative force is maximal, appears to cause no difficulties. Whether or not very transient and minimal redistribution of the volume of the circulating blood may be a problem under conditions of take-off in patients with advanced cardiovascular disease can be only speculative at this time. It may be theorized, for example, that minimal pooling of the blood footward in patients with severe hypotension may cause transient symptoms.

### NOISE AND VIBRATION

Noise and vibration have been considerably minimized with the advent of the commercial jet-propelled airplane. From a physiologic point of view, noise and vibration pose no practical problem as far as passenger travel on jet-propelled airplanes is concerned. Noise and vibration may have some causative effect in producing fatigue in the piston-driven type of aircraft, depending upon such factors as the duration of the flight and the type of patient involved.

### TURBULENCE

Turbulence is primarily responsible for the occurrence of motion sickness, which difficulty is believed to be due principally to the effect of linear vertical motion upon the vestibular organs. With the increase in the cruising altitude at which the commercial jet-propelled airplane flies, the degree of turbulence is minimized. Psychologic and physiologic factors must be considered in determining whether or not a given patient can fly, because these factors may predispose the person to airsickness. In many instances the threshold to motion sickness may be increased by medication administered prior to flight. Drugs antagonistic to motion sickness are now available as over-the-counter nonprescription items. Examples are cyclizine hydrochloride (Marezine hydrochloride), meclizine hydrochloride (Bonamine) and dimenhydrinate (Dramamine). Other factors which will decrease the sensitivity to motion are flying at night to reduce visual stimulation, sitting in a reclining position and occupying a seat toward the center of gravity of the airplane.

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### EFFECTS OF PROLONGED IMMOBILIZATION

Ordinarily the average airplane passenger remains seated relatively immobile for almost the entire duration of the journey. The average duration of a given flight, however, is being reduced appreciably now, since the advent of the jet-propelled airplane.

### CONTRAINDICATIONS TO FLIGHT AND SPECIAL PRECAUTIONS

A few medical conditions require caution on the part of the physician in the consideration of patients for air travel to preclude the development of unpleasant and sometimes serious complications. Three principles must be kept uppermost in mind in the determination of whether or not a person is physically and emotionally fit to travel by air.

1. A passenger must have no interference with the supply of oxygen to the lungs.
2. The mechanical expansion of gases in the air traveler must be unobstructed.
3. The passenger must not impose any untoward effects upon the sensibilities, security, and health of his fellow passengers.

Some authors have presented exaggerated medical contraindications to flight and have discussed clinical and pathologic conditions in which flying certainly would be ill advised. This has caused some physicians to advise their patients not to travel by air, thereby depriving the patients of the advantages of economical, speedy, comfortable and safe transportation by air. Physicians can do much to allay the fears and misconceptions of their patients in respect to air travel and should be qualified to give sound medical advice in this field, a word of caution when advisable, and hearty reassurance to those who need it. Intelligent guidance and advice will go far in preventing medical and surgical difficulties during flight. There are not many absolute contraindications to the travel of passengers by air, and these few are based upon an understanding of the physics of the atmosphere, the physiologic functions of the body, and the pathologic nature and manifestations of the disease.

Medical contraindications to travel by air will be divided into major organ systems: cardiovascular, gastrointestinal, bronchopulmonary, neuropsychiatric, ear, nose and throat, and miscellaneous. Because of the lack of medical facilities and trained medical personnel aboard commercial aircraft, and in consideration of the comfort of other passengers, some restrictions must be applied to travel of certain patient-passenger types.

### CONTRAINDICATIONS ACCORDING TO TYPE OF PATIENT

1. Persons who have malodorous conditions, gross disfigurement, or other unpleasant characteristics which might offend fellow passengers should not be transported by public air carrier unless physical isolation can be assured.
2. Persons who have contagious diseases or who are acutely ill or in a critical condition should not be carried on commercial aircraft.
3. Persons who cannot take care of their own physical needs should not be transported unless, by previous arrangement, a suitable attendant accompanies them.
4. Persons whose behavior might be disturbing or hazardous to other passengers should not be carried on aircraft. This restriction also applies to difficult and badly behaved children and to persons who might become emotionally disturbed.

### CONTRAINDICATIONS ACCORDING TO AFFECTIONS OF ORGAN SYSTEMS

#### Cardiovascular

Persons who have minimal cardiac reserve should travel by air only if oxygen is immediately available for their needs. The same is true of patients recovering from congestive heart failure or recent myocardial infarction. The type of aircraft to be used and the determination of whether or not the airplane is pressurized must be taken into consideration when this type of traveler is being advised. It has been said that if a person is able to walk 100 yards and to climb twelve steps without manifesting symptoms, flight in pressurized aircraft is permissible. Persons who exhibit cyanosis, severe disturbances of rhythm, persistent

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arrhythmias resulting in recurrent prostration, syncope or shocklike conditions, those with markedly enlarged hearts, extreme valvular stenosis, convalescent myocardial infarction, marked exertional angina, severe hypertension and hypertensive encephalopathy or any other condition which restricts the cardiac reserve to such an extent as to render the patient unable to climb one flight of stairs without production of symptoms or severe dyspnea should be carefully evaluated before they are advised that air flight is safe for them.

It is to be noted here that all the foregoing remarks are applicable to commercial air travel and not to the transportation of patients by air or by air-ambulance. (The American College of Chest Physicians has devised a detailed system of guidance which concerns air travel dependent upon cabin altitudes of 6,000 and 8,000 feet. In essence, the College suggests that those who have major cardiac disorders but adequate functional reserve at sea level may travel at a cabin altitude of 8,000 feet, and that those who have cardiac conditions in which myocardial oxygenation is marginal should not travel at cabin altitudes of more than 6,000 feet.)

Patients with histories of previous or existing thrombotic or venous disease should be instructed against remaining immobile for long periods during air flight. Immobility and the associated venous stasis in the limbs are believed to be important factors in the development of "passenger phlebitis" which may result in pulmonary infarction.

### *Bronchopulmonary*

*Asthma.*—Apparently there is no contraindication to air travel on the part of an asthmatic person if his condition can be controlled with medication and if oxygen is available for his needs. In a study of patients with pulmonary conditions transported on nonpressurized U. S. Air Force air-evacuation aircraft flying at altitudes of less than 10,000 feet, 215 patients had asthmatic conditions, and symptoms developed in only six, three of whom were seized by acute asthmatic attacks.

*Pneumothorax.*—Patients for whom artificial pneumothorax has been established should be cautioned not to fly immediately after a refill, an interval of ten days after this procedure usually being recommended before such patients can embark on aerial flights. The vast majority of such patients will encounter very little difficulty in air travel, but careful evaluation is indicated to ascertain such knowledge as size and expected expansion of the entrapped gas in the presence of a large or unstable pneumothorax.

*Pulmonary Tuberculosis.*—A patient with suspected pulmonary tuberculosis should be advised not to fly, not because of any threat to his own health but because the communicable nature of the disease and the public health problem which it presents.

*Vital Capacity:* Persons whose vital capacity is 50 per cent or less do not do well in unpressurized aircraft unless a flight altitude of less than 5,000 feet is maintained. Pulmonary function and reserve should be evaluated in order to determine whether persons with pulmonary emphysema or severely limited ventilation, arising from pulmonary fibrosis, should travel by air. Pulmonary secretions tend to thicken in the drier air present in flight, and difficulty with coughing and expectoration may be encountered.

*Air Hunger.*—Air hunger is associated with a lessened amount of available oxygen in the ambient atmosphere at higher altitudes, due to the decreased partial pressure of oxygen. This condition is encountered most commonly in unpressurized aircraft, or those pressurized airliners in which the cabin pressurization system is not operating efficiently. True air hunger is physiologic. Frequently, however, such a state is mistakenly associated with hyperventilation or a dyspneic type of respiration which generally is the result of apprehension or anxiety. In the presence of true air hunger supplementary oxygen will alleviate the symptoms. When the dyspneic type of respiration resulting from anxiety is at hand the inhalation of carbon dioxide, rebreathing with a paper bag

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or simple holding of the breath will bring prompt relief. If oxygen is administered over long periods carpopedal spasm may develop. Reassurance is calming and has a very beneficial effect in both situations. Hyperpneic tetany arising from hyperventilation is not ordinarily a cause for an unscheduled landing.

### *Gastrointestinal*

Expansion of intestinal gases ordinarily is easily handled by eructation or expulsion of flatus. Occasionally, however, problems are encountered among persons who have a spastic gastrointestinal tract. Distention of the bowel in such persons can result in severe pain which progresses, in some, to shocklike conditions. Antispasmodic medication before an air flight will aid such travelers. The condition of persons who recently have undergone intestinal operations should be evaluated carefully before such persons are advised whether or not flight is permissible for them. Since expansion of intestinal gases is approximately 50 per cent at an altitude of 10,000 feet and 100 per cent at one of 18,000 feet, disruption of a recently performed intestinal surgical procedure could result in peritoneal soiling or some other post-operative catastrophe. It is advisable that a 10-day delay in air travel be proposed after an operation. Persons who have undergone colostomy should be warned of the problem of expansion of intestinal gases, and it is well to suggest that they use a slightly larger colostomy bag during flight.

### *Neuropsychiatric*

The safety of the other passengers and crew should be evaluated when a person in a psychiatric state is being considered for travel by air. Persons manifesting unpredictable behavior or those who require heavy sedation or restraint should not fly on commercial transports. However, the judicious use of ataractic medication should reduce the incidence of neuropsychiatric problems.

*Epilepsy.*—Epileptic persons appear to be more susceptible to convulsive seizures in air-

craft than elsewhere. This tendency appears to be due to a combination of factors, such as reduced oxygen, hyperventilation, and apprehension. Epileptic persons subject to frequent seizures should travel with a companion when this is at all possible. Sedation before the flight, reassurance, and proper oxygenation during flight usually permit epileptic persons to travel satisfactorily by air provided the aircraft is pressurized to the extent that the simulated cabin altitude will not exceed 8,000 feet.

*Motion Sickness.*—This no longer is a major issue in present-day air line operation. It is, however, still the most common physiologic disturbance associated with flight and the cause is closely related to turbulence, although angular acceleration, caused by the motion of the aircraft, also is a basic cause. The underlying factors of anxiety, apprehension and fear are strong predisposing influences. Discomfort and emesis are more frequent in women than in men, and children are the least susceptible. The incidence of motion sickness decreases with age and experience in travel. Modern jet-propelled transports with cabin-pressurization systems are capable of flying over loci of bad weather and turbulence and consequently provide smoother flights with a reduced incidence of motion sickness.

It has been postulated that the fear of motion sickness itself probably hastens the development and appearance of the characteristic symptom complex. Most turns in aerial traffic are to the left. Practical advice for those who are susceptible to the development of motion sickness is to avoid window seats on the left, secure a seat at the root of a wing, and place the seat in the reclining position. These precautions, with assurance by the physician and flight attendants and premedication with one of the anti-motion sickness agents, will reduce the incidence of this condition. Other suggestions, such as abstinence from alcohol prior to or during flight, and the taking of a light meal prior to embarking, also are valuable.

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### *Ear, Nose, and Throat*

Equalization of pressure in the accessory nasal sinuses is basically automatic, but it may be interfered with by such conditions as swollen or redundant mucosa or nasal polyps. Infections and affections of the upper part of the respiratory tract are the chief etiologic factors in aerotitis media—more recently called “barotitis media”—and of barosinusitis. Persons who have acute respiratory infections, allergic rhinitis or nasal polyposis should be advised to use nasal vasoconstricting or decongestant agents during flight and particularly prior to ascent and descent. It is unwise for persons with sinusitis or otitis media to fly during the acute stage of the disease. Infants should be given a bottle or the breast during descent so that their eustachian tubes will be kept open by swallowing movements. Persons who have undergone fenestration operations might experience vertigo during steep turns and banks of the aircraft. It is wise to advise such persons to be certain that the canal of the affected ear is dry prior to ascent or descent.

Persons who have sustained a fracture of the mandible for which permanent wiring of the jaws has been done should not travel by air because of the possibility of motion sickness, emesis, and aspiration of the vomitus. Several quick-release mechanisms have been developed, such as rip cords, cotterpins, or rubber-band devices, which can be used if such a situation should develop. If mandibular fixation is modified by such a mechanism, opening of the mouth can be accomplished in the event of air sickness and vomiting. Patients with mandibular fixation modified by such an emergency device can travel by air. They should be adequately forewarned of the difficulties and should be able to take care of themselves. Premedication with the antimotion sickness agents referred to herein may be desirable. Many of these can be obtained in liquid form.

The changes in barometric pressure which occur with changes in altitude are the basic reasons for difficulty with the ears during flight. In the normal ear equalization of pressure be-

tween the middle ear and the ambient atmosphere is achieved automatically upon ascent. During descent, however, conscious voluntary actions (swallowing or yawning) must be undertaken to gain and to maintain equilibrium between the pressure in the middle ear and that in the cabin. These actions are necessary because of the anatomic aspects of the eustachian tube and the flutter-valve type of proximal orifice of the tube. Thus, since difficulty with the ears arises almost entirely during descent, the air lines routinely maintain a gradual rate of descent. It is usually at this time that chewing gum or mints are distributed to the passengers, since chewing and swallowing periodically open the valvular pharyngeal end of the eustachian tube.

### MISCELLANEOUS

This section deals with anemia, sickle-cell disease, problems associated with infants and the aged, difficulties with the eyes, pregnancy, and diabetes.

*Anemia.*—Severe anemia or blood dyscrasia of any type which interferes with oxygen transport usually produces anemic hypoxia and impairs the physiologic response to mild degrees of hypoxia. Oxygen should be instantly available to the passenger who is suffering from severe anemia. Severe anemia exists when the content of hemoglobin is less than 8.5 gm. per 100 ml. of blood or when erythrocytes number less than 3,000,000 per cubic millimeter of blood.

*Sickle-Cell Disease.*—Of recent and mounting interest is the problem of sickle-cell disease found in Negroes. This hemolytic disorder is present in approximately 5 per cent of the general Negro population. It has been demonstrated that in the presence of mild-to-moderate deficiency of circulatory oxygen, to the degree encountered in unpressurized cabins at altitudes of 8,000 to 14,000 feet, sickling and hemolysis may take place in those persons with this disorder. More than thirty cases of sickle-cell anemia and instances of abdominal pain or pain in the left upper abdominal quadrant, nausea and vomit-

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ing in flight and splenic infarction have been reported. Instances of this type have been reported to occur in Negroes after flying at a simulated cabin altitude of only 4,000 to 6,000 feet. Paper electrophoresis of hemoglobin has been instrumental in identifying these persons. It is not absolutely necessary that frank sickle-cell disease (pure S hemoglobin) be present, since several of the patients have had only the sickle-cell trait. All of these patients had hemoglobin C, which strongly suggests that persons in whom analysis discloses the presence of S and C hemoglobins should be advised not to fly. Although the incidence of this condition is relatively low, it should not be overlooked, and Negro passengers would be well advised to notify the flight attendant if they experience abdominal discomfort or pain. The early administration of oxygen tends to prevent additional symptoms. Since it is to the advantage of the Negro passenger to know for certain whether he possesses the sickling trait, a determination of hemoglobin by means of paper electrophoresis certainly is advisable. The type of hemoglobin concerned is an inherited characteristic.

*Infants.*—Infants seven days old and older may be transported by air. Prior to such an age their respiratory mechanisms are not yet sufficiently firmly established to allow them to tolerate the respiratory stresses which may be encountered in flight. Beyond the age of seven days to two weeks, infants with a normal cardiorespiratory system should experience no difficulty. Infants tolerate hypoxia better than do adult persons.

*The Aged.*—Old people with well-compensated cardiovascular and respiratory systems tolerate air flight excellently. There are no contraindications to flying based on advanced age alone.

*Ophthalmic Conditions.*—Since, during treatment of an injured eye or after operation upon an eye, air may have been injected into the anterior chamber to preserve the shape of the globe, the physician who has had such a patient should be aware of the problem of expanding

gases in flight. When such patients travel by air, the simulated cabin altitude should not exceed 4,000 to 5,000 feet. Since the retina has the highest oxygen demand of any tissue of the body, patients with serious ophthalmic conditions should be provided with oxygen if they must travel at a cabin altitude in excess of 5,000 feet. It has been demonstrated that at altitudes of more than 10,000 feet hyoxia produces dilatation of the retinal and choroidal blood vessels, a measurable increase in intraocular tension, and a reduction in diameter of the pupil. These effects, singly or in combination, are detrimental to the injured, postsurgical, or glaucomatous eye. Most commercial air lines will allow a blind passenger with a seeing-eye dog to travel in the passenger compartment if the dog is properly muzzled and is secured on a short lead. It is important that the blind traveler be properly oriented in the aircraft to prevent confusion in the event of an emergency.

*Pregnancy.*—Physicians generally agree that a woman in uncomplicated pregnancy is not sick, and that she is a normal person undergoing a normal physiologic process. Most air lines feel that the only contraindication to air transport of the pregnant woman is the danger of precipitous delivery during flight. All air lines accept pregnant women during the seventh month of gestation and most lines will transport those who are in the eighth month. To be accepted for air transport during the ninth month, the pregnant woman must present a certificate signed by her physician certifying that he has examined her within seventy-two hours of departure and has found her to be physically fit for transportation by air and has set down the estimated date of birth.

The following is the policy recommended by the Airline Medical Directors' Association:

Any woman in a pregnant condition shall be accepted from the beginning of the first month on through to the end of the eighth month of gestation without question. Any woman in the ninth or last month of pregnancy shall be accepted who can furnish a certificate from an obstetrician dated within seventy-two hours of departure, stating that he has examined and found her to be physically fit for trans-

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portation from (place) to (place) on (date) and that the estimated time for birth of the baby is (date).

Pregnant travelers should select rearward-facing seats, if possible, to allow use of a loosely fastened seat belt across the thighs, under the fetal bulge. In women near term it is not unusual for false labor pains to develop within a day or so after flight, and any woman traveling by air in the later stages of pregnancy should be forewarned that such pains may occur.

A study of abortion in 1,000 women of ages sixteen to forty-two years traveling by air during World War II revealed no correlation between abortion and flying. Air travel is not harmful to a normal pregnancy, regardless of the duration of the pregnancy. No reliable reports of deleterious effects to the unborn child or mother, caused by premature labor or hypoxia at the altitudes traveled by commercial aircraft of any type, have been published.

*Diabetes Mellitus.*—Diabetes mellitus is no contraindication to travel by air. Those who require insulin should be instructed to carry their insulin and syringe with them in their hand baggage and to be certain that insulin and syringe are available to them in the passenger cabin. Those who are maintained on oral hypoglycemic medication should have a candy bar or sugar cubes, as well as their medication, available in their hand baggage. Diabetic persons whose disease is not well controlled are more subject to hypoxia if the blood sugar is lowered to values at which hypoglycemia occurs.

*Poliomyelitis.*—Patients who have had poliomyelitis are acceptable for air travel provided one month has elapsed since the onset of the disease, the disease generally being considered to be noninfectious after such a period. If the patient is not ambulatory a special attendant is required. Occasionally, special arrangements can be made with some air lines to transport persons recovered from the bulbar type of poliomyelitis. In this type of case, preparation must be made by the air line concerned to have the proper power supply (correct voltage and

wattage) for activation of the portable respirator, if this apparatus is required.

*Communicable Diseases.*—Patients with communicable diseases are not accepted for flight because of the danger to the other passengers. Violation of public health directives should be guarded against. Particular care must be taken to avoid air transportation of persons with any of the international quarantinable diseases: smallpox, cholera, plague, typhus, relapsing fever, and yellow fever.

*Other Conditions.*—Some persons and patients require careful study and, if they are transported, special handling. These include patients with mediastinal tumors, extremely large unsupported hernias, intestinal obstruction, cranial diseases involving increased pressure, disturbance of the cerebrospinal circulation, tumor of the brain or fracture of the skull, injuries to the spinal cord, recent cerebrovascular accidents and angioneurotic edema with a history of laryngeal involvement. Patients who have sustained multiple fractures and prospective passengers wearing body casts also should be considered carefully. In general, casts affixed within twenty-four hours of flight should be bivalve to assure access during air transportation, if such is required.

### SUMMARY

An ever-increasing number of people have found that travel by air is safe, swift and comfortable. Many such people may have, or some day may have, a serious illness.

When a patient is under consideration as a potential passenger on a commercial air line, certain basic principles must be reviewed. The most salient consideration is whether or not the patient should be moved by any means. The next step is to determine if the commercial air line represents the most desirable method for all concerned, taking the welfare of the other passengers into consideration. Furthermore, the patient's clinical condition should be stabilized.

Because of certain physiologic factors concerned with altitude, a knowledge of the various

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airplane pressurization systems is important. Similarly, certain information about operations, such as duration of flight and a transfer of plane, is of considerable importance to the patient.

Dysbarism and hypoxia are two conditions which may impair physiologic response in normal passengers but more particularly so in patients with a clinical disorder. Cabin pressurization has done much to minimize these two conditions, but they may be of some consequence in the presence of disease.

More frequently, travel by air has been found to be the most expeditious and desirable form of travel for patients with certain types of illness. Some patients may need a certain amount of preparation, but only a few will find that their condition makes it undesirable for them to travel by air.

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## Biological Effects of Magnetic Fields — Negative Results

JOHN E. EISELEIN, B.S., HELEN M. BOUTELL, B.S. and MAX W. BIGGS, M.D., PH.D.

CERTAIN propulsion systems theoretically useful in space vehicles would employ strong magnetic fields in their design. Alexander<sup>1</sup> has recently reviewed the subject of "Biomagnetics," and on the basis of the published literature has pointed up the need for further

Atomic Energy Industry are exposed to magnetic fields of varying intensities in the course of operation and maintenance of various ion accelerators. Clinical signs or symptoms of biological effects have not been observed in these employees, with the exception of the

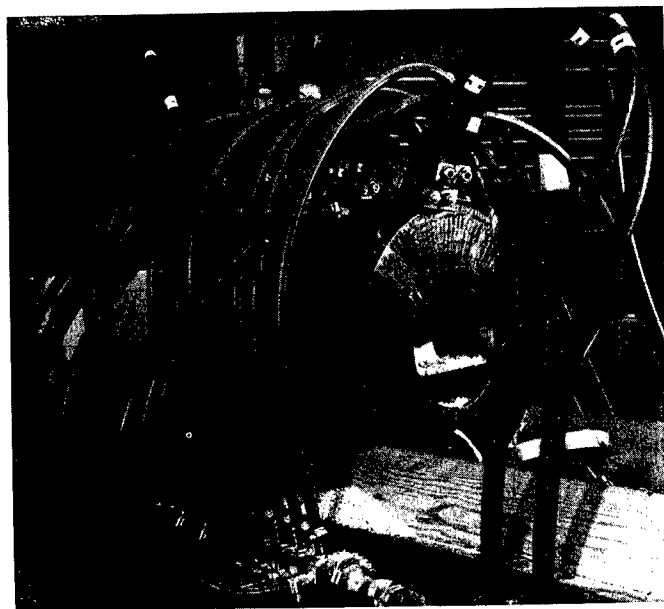


Fig. 1. The electromagnet housed a stainless steel cylinder with two levels for mouse occupancy. The end cover has been removed in the photograph to demonstrate this feature. The magnet was water-cooled and temperatures in the animal chamber were constantly monitored with a thermocouple gage.

studies on the biological effects of magnetic fields. On the basis of this evidence he points to a need for caution when humans are subjected to a powerful magnetic field.

Physicists and accelerator operators in the

"magnetic phosphene" or flash of light seen when the head is in an undulating field.

Barnothy and Barnothy<sup>2,4,5</sup> and Barnothy, Barnothy and Boszormenyi-Nagy<sup>3</sup> have reported a variety of biological effects in mice attributed to exposure to a magnetic field. Included among the variety of effects reported by these authors

From the Lawrence Radiation Laboratory, University of California, Livermore, California.

are: (1) retardation of tumor growth, (2) retardation of animal growth and (3) alterations in the white blood count. The following experiment was done to extend these particular observations.

#### EXPERIMENTAL

**Magnet Description.**—The magnet used was a large air-core electromagnet. The cylindrical space within the magnet measured 23 cm. in diameter and 60 cm. in length. The mice were housed within this core, in a stainless steel container which allowed random movement. The equipment is shown in Fig. 1. The magnet was water-cooled; however, it was necessary to circulate air at 70 degrees F. through the tube to maintain an acceptable temperature of approximately 70 degrees F. in the living space of the animals.

Measurements of the magnetic field strength within the magnet core over any plane at right angles to the long axis of the core were identical within experimental error. The field strength along the long axis of the magnet core varied appreciably (8,800 to 14,400 gauss). A plot of the field strength as a function of position along the axis within the animal tube is given in Fig. 2. Movements of the animals within the tube were not restricted, so part of the time the animals resided in a nearly constant field of 13,500 to 14,400 gauss. Approaching the ends of the core the field gradient was approximately 400 gauss per centimeter.

Control animals were housed in the same room in an identical stainless steel container. Heating pads were wrapped about the container of the control animals to simulate the warming effect of the magnet. A similar circulation of 70 degree F. air was forced through the container as for the experimental animals.

The containers allowed the use of up to eighty mice in the experimental group and a similar number in the control group at any one time.

The magnet was operated continuously twenty-four hours per day during the experimental periods.

**Ehrlich's Ascites Tumor Growth.**—One hundred and forty White Swiss female mice, weighing approximately 22 gm. each, were injected intraperitoneally with  $1 \times 10^6$  ascites tumor

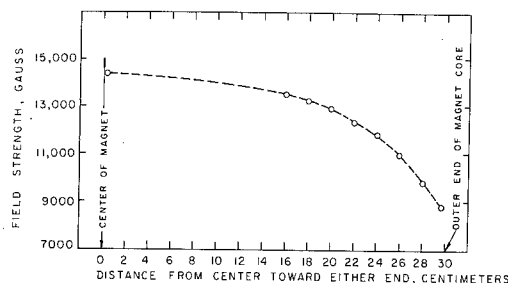


Fig. 2. The field strength is plotted as a function of position along the axis of the magnet core.

cells. Immediately after injection, seventy animals were placed in the magnetic field; seventy animals in the control cage. Approximately ten animals were killed from both the experimental and control groups at 36 hours; 2½ days, 3½ days, 4½ days, 6½ days and 8½ days. The remaining animals in each group were allowed to remain in the magnet and control cage until death occurred.

At the time of sacrifice the animals were killed with ether. The ascitic fluid volume was calculated from a measurement of the ascitic fluid specific activity following injection of a known amount of  $I^{131}$  labeled human albumen solution. Ascitic fluid was taken for tumor cell counts and tumor cell volume determinations.

**Animal Growth Rate.**—Forty male White Swiss mice, approximately three weeks old, were divided into two groups. The body weight of the animals in each group averaged 12.2 gm. One group of twenty animals was placed in the magnet; a second group of twenty was placed in the control cage. These two groups were weighed at frequent intervals for a period of eleven days. The experimental animals were removed from the magnet at the end of eleven days and the growth rate measured for an ensuing eleven days.

A second growth rate experiment was re-

# BIOLOGICAL EFFECTS OF MAGNETIC FIELDS—EISELEIN ET AL

TABLE I. ASCITES TUMOR GROWTH RATE IN MICE RETAINED IN THE MAGNET THROUGHOUT THE PERIOD OF TUMOR GROWTH VERSUS ASCITES TUMOR GROWTH RATE IN CONTROL ANIMALS

Animal Group	Number of Animals	Days After Tumor Implant	Mean Total Tumor Cell Count* (X10 <sup>6</sup> )	Mean Total Tumor Volume* (ml.)	Mean Animal Weights (gm.)
Experimental	10	1½	6.8 ± 0.9	0.028 ± 0.003	22.7
Control	9	1½	10.6 ± 1.2	.035 ± .002	21.8
Experimental	9	2½	26.0 ± 2.0	.064 ± .007	22.5
Control	10	2½	26.8 ± 3.5	.061 ± .005	23.2
Experimental	9	3½	73.1 ± 7	.141 ± .011	22.6
Control	9	3½	97.7 ± 13	.186 ± .058	23.7
Experimental	9	4½	141 ± 7	.241 ± .014	22.5
Control	10	4½	167 ± 16	.327 ± .026	24.9
Experimental	9	6½	317 ± 31	.822 ± .073	26.4
Control	10	6½	318 ± 28	.817 ± .074	27.2
Experimental	7	8½	631 ± 64	1.89 ± .20	33.2
Control	8	8½	669 ± 76	1.95 ± .17	30.9

\*Including standard error of the mean.

TABLE II. GROWTH RATE OF 20 ANIMALS MAINTAINED IN THE MAGNETIC FIELD FOR 11 DAYS COMPARED TO THE GROWTH RATE OF 20 CONTROL ANIMALS

(The growth rate for twelve days following removal of the experimental animals from the magnet is included.)

Days in the Magnet	Experimental Group Weight in Grams*	Control Group Weight in Grams*
Start	12.2 ± 0.2	12.2 ± 0.2
1	13.1 ± 0.2	13.5 ± 0.2
2	14.2 ± 0.2	14.4 ± 0.2
3	15.4 ± 0.4	15.2 ± 0.1
4	16.7 ± 0.4	16.5 ± 0.3
6	19.5 ± 0.6	18.3 ± 0.6
8	20.8 ± 0.6	20.5 ± 0.7
11	22.0 ± 0.6	22.7 ± 0.5
Days after removal from magnet		
2	24.8 ± 0.6	23.7 ± 0.6
8	29.7 ± 0.6	27.0 ± 0.6
12	30.1 ± 0.7	28.8 ± 0.7

\*Including standard error

peated using eighty male White Swiss animals, mean weight: experimental 13.5 gm., control 13.6 gm. Forty were placed in the magnet; forty were used as controls. Mean weights of each group were measured at the beginning of the experiment and at day 9, 10, 11, 12 and 15.

**Blood Counts.**—The animals used for the growth observations above were sacrificed in groups of about eight for white blood count, red blood count, hematocrit and white cell differential count. The animals were killed with a blow to the head. The thorax was quickly

opened and heart blood was taken for the measurements. Observations were made after 16, 17, 20, 23 and 25 days of exposure to the magnetic field.

## RESULTS

**Ascites Tumor Growth.**—Under the conditions of the experiment, the rate of growth of the ascites tumor was not significantly altered by the magnetic field. The data are summarized in Table I.

Twelve experimental animals were allowed to live in the magnet until death. The mean survival time was 11.3 ± 0.8 days. Nine control animals were left alone until death. The mean survival time was 13.1 ± 1.2 days.

**Growth Rate.**—The mice maintained in the magnet did not show a significant change in growth rate when compared with the growth rate of the animals in the control cage. The data are tabulated in Tables II and III for the two growth rate experiments.

**Blood Counts.**—No significant alterations in the white blood count, differential blood count, hematocrit, red blood count or liver and spleen weights were observed.

Data on the white blood counts are tabulated in Table IV. The mean red blood count for the thirty-one experimental animals held in the magnet from sixteen to twenty-three days was

# BIOLOGICAL EFFECTS OF MAGNETIC FIELDS—EISELEIN ET AL

$7.56 \times 10^6$  cells per cubic mm. The mean value for the thirty control animals was  $7.32 \times 10^6$  cells per cubic mm. The mean hematocrit values were: experimental 41.9 per cent, controls 40.9 per cent. The mean spleen weights were: experimental 0.13 gm., control 0.14 gm. The mean liver weights were: experimental 1.35 gm., control 1.41 gm. The mean white blood cell differential counts for the thirty control animals were: lymphocytes 88 per cent, polymorphonuclear leukocytes 7 per cent, monocytes 5 per cent, eosinophiles less than 1 per cent.

TABLE III. MEAN WEIGHTS FOR FORTY ANIMALS MAINTAINED IN THE MAGNETIC FIELD FOR FIFTEEN DAYS COMPARED TO THE MEAN WEIGHTS FOR FORTY CONTROL ANIMALS

Days in the Magnet	Experimental Group Weight in Grams	Control Group Weight in Grams
Start	13.5 ± 0.2	13.6 ± 0.2
9	23.6 ± 0.4	24.0 ± 0.4
10	23.7 ± 0.4	24.6 ± 0.4
11	24.3 ± 0.5	24.8 ± 0.4
12	25.9 ± 0.4	26.4 ± 0.4
15	26.8 ± 0.4	27.1 ± 0.4

For the thirty-one experimental animals the values were: lymphocytes 88 per cent, polymorphonuclear leukocytes 8 per cent, monocytes 4 per cent, eosinophiles less than 1 per cent. No pathological cells were noted in the smears.

## SUMMARY

Attempts to demonstrate a significant biological effect of a sustained magnetic field (8,800 to 14,400 gauss) on White Swiss mice were unsuccessful. Under the conditions of the experiments the magnetic field did not alter the rate of growth of an Ehrlich's ascites tumor, it did not significantly change the rate of young

TABLE IV. TOTAL WHITE BLOOD COUNT (HEART BLOOD) OF ANIMALS MAINTAINED IN THE MAGNETIC FIELD VERSUS CONTROL ANIMALS

Group Designation	Number of Animals	Days in the Magnet	Mean White Blood Count* (X10 <sup>3</sup> )/mm <sup>3</sup>
Experimental	7	16	6.6 ± 0.8
Control	7	—	3.8 ± 1.0
Experimental	8	17	3.1 ± 0.3
Control	8	—	3.7 ± 0.6
Experimental	8	20	3.5 ± 0.3
Control	8	—	3.6 ± 0.3
Experimental	8	23	2.8 ± 0.4
Control	7	—	2.5 ± 0.2
		Days after removal from Magnet	
Experimental	7	8	3.6 ± 0.5
Control	9	—	3.4 ± 0.6

\*Includes standard error

male animal growth, and it did not significantly change the white blood count.

## ACKNOWLEDGMENT

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# Psychobiologic Effects of Water-Immersion-Induced Hypodynamics

CAPTAIN DUANE E. GRAVELINE, USAF, MC, BRUNO BALKE, M.D., CAPTAIN RICHARD  
E. MCKENZIE, USAF, MSC and BRYCE HARTMAN, PH.D.

**O**F THE many biomedical problems that man will encounter in eventual space flight, prolonged weightlessness is the most difficult to evaluate. Having evolved in the normal gravitational field of the Earth, man will find that the muscular efforts, consciously or subconsciously needed in normal life, will be markedly reduced in a floating type of existence. That component of muscular tone previously required to maintain, for instance, the erect posture in a one-G environment will be diminished considerably. Although a certain amount of energy will be expended in manipulating controls and overcoming inertial effects, the energy expenditure will be less than during similar activity under normal gravitational conditions. This effect will be apparent whether man remains strapped to a seat during his space journey or is allowed to move freely about the cabin. To move an object or one's self (slowly) across the cabin will require only relatively slight muscular efforts to overcome inertial effects. As a consequence, muscular hypotonicity or even atrophy can be expected to occur. Certain cardiovascular changes may also result due to lack of normal hydrostatic pressure of the blood column as well as due to the lack of normal muscular support. Such changes may demonstrate the adaptability of the human organism to any environmental situation; however, in the case of the astronaut, such adaptations are undesirable in that they may deprive him of the biodynamic potential to survive gravitational re-entry stresses.

At the present time, a weightless condition of

less than one minute's duration can be obtained by the use of aircraft flying a Keplerian trajectory. For simulation of prolonged zero-gravity other techniques must be employed. Water immersion offers one approach which approximates some of the effects of weightlessness, particularly with respect to the musculoskeletal system. Normal gravitational influences are still present on the body; however, as in the zero-gravity state, there is a marked decrease in the amount of muscular effort required for almost all activities. Man is then in a state of "Hypodynamics." This area of research is new to the field of Space Medicine. The study of hypodynamics deals with the metabolic and functional responses of the body to a state of relative muscular inactivity, first by assessing qualitatively and quantitatively these responses, then by evaluating various preventive measures designed to protect the body against these debilitating adaptive changes.

The physiologic responses to prolonged muscular inactivity have been studied by Taylor, Henschel, Brozek and Keys.<sup>8</sup> These investigators found a marked deterioration in the cardiovascular response to posture changes after a three-to-four week period of bed rest as measured pulse rate and blood pressure changes in tilt-table experiences. The resting pulse rate was higher than it was before and during an exercise test, while the "normal" working pulse rate was surpassed by 40 beats per minute with workload held constant.

Deitrick, Whedon and Shorr<sup>2</sup> extended their studies of four normal, healthy men to include metabolic responses to prolonged muscular inactivity. In addition to cardiovascular deteriora-

From the School of Aviation Medicine, Aerospace Medical Center, Brooks Air Force Base, Texas.

## WATER-IMMERSION INDUCED HYPODYNAMICS—GRAVELINE ET AL

tion, they were able to demonstrate marked increases in nitrogen excretion. The calcium content of the urine was doubled during the fourth and fifth weeks on immobilization. Also noted

mal weight sensation is altered and movement is effortless. A pilot experiment of two day's duration was followed by another experiment extended to a maximum time of tolerance. Med-

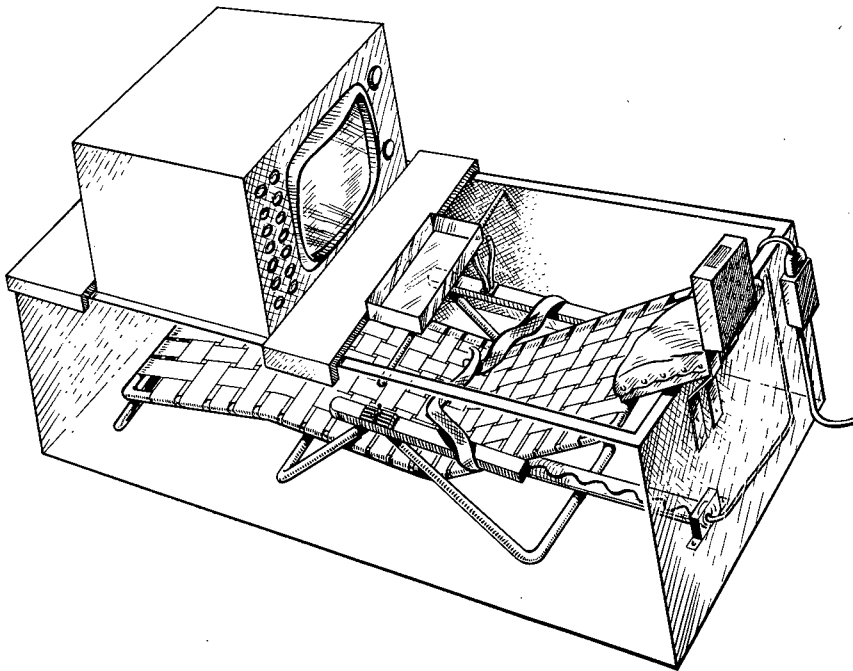


Fig. 1. View of tank and subject's console.

was increased excretion of phosphorus, sulfur, sodium and potassium. A significant decrease in muscle mass and muscle strength was accompanied by a definite lowering of creatinine tolerance.

In previous studies<sup>1,4</sup> we investigated normal young men before and after two-week periods of absolute bed rest and found remarkable functional deterioration. Compensation of the cardiovascular system to positional changes as measured by the tilt-table was markedly impaired. Treadmill studies showed up to 30 per cent decrease in the respiratory and cardiovascular adaptability to provide a maximum of aerobic oxygen supply during work.

The present study involves the use of water immersion to approximate the hypodynamic effect of weightlessness. Supported by water, nor-

mal weight sensation is altered and movement is effortless. A pilot experiment of two day's duration was followed by another experiment extended to a maximum time of tolerance. Med-

### MATERIALS AND METHODS

A tank was constructed of sufficient size to allow immersion of the subject in a semireclining position. A form-fitting couch was installed in the tank to insure a stable position from which the subject could perform various manipulative tasks. The experimental setup is depicted in Figure 1. An automatic heating device maintained the water temperature at 33.5 degrees Centigrade. The subject, clad in a rubber suit of conventional SCUBA design, was immersed in the water up to his neck with his head supported by a padded rest. The remainder of the body was supported by the water in accordance with Archimedes' principle. The re-

sultant specific gravity of the subject was very close to 1.0, and under these conditions movements of the trunk and extremities were effortless.

The subject's diet for a continuous five-week period was Sustagen, a powder containing all the necessary nutritional and caloric requirements. Mixed with water, it is taken in the manner of a milkshake. In addition to being low residue, this type of diet minimized the food preparation and feeding problem. Due to its constant known composition, accurate intake values of the various components of the diet were recorded as a necessary requirement for the metabolic evaluations. These metabolic studies included the determination of urinary and serum calcium, phosphorus, sodium, potassium, chlorides, corticosteroids, urinary catecholamines, total urinary nitrogen, total serum protein, serum protein electrophoretic pattern and serum transaminase. Hematologic data included complete blood count, sedimentation rate and hematocrit. Blood volume was determined by the Evans Blue dye technique. In addition to this type of assessment, there were functional studies before and after the seven-day water immersion. These included tests of orthostatic tolerance on the tilt-table, work capacity on the treadmill, centrifuge profiles and in-flight testing of G-tolerance, and electrocardiographic tracings, blood pressure, pulse rate, ventilatory volumes, metabolic rate, oral temperatures, and electroencephalographic tracings (for monitoring sleep) were obtained at regular intervals.

To evaluate sleep characteristics, two different kinds of EEG data were obtained: (1) standard clinical records for the pre-immersion and post-recovery periods, and (2) records monitoring sleep while immersed. The standard clinical EEG's were conventional runs with natural sleep, hyperventilation and photic stimulation. The pre-immersion record was made on the day before the week in the tank and the control record was made one week after leaving the tank. Conventional arrangements of eight leads on both monopolar and bipolar runs were re-

corded, using needle electrodes. Records for studying sleep during immersion were obtained in the regular sleep period scheduled from 0400 to 0800 hours each day. Sleep states were measured on a sampling basis, with six fifteen-minute runs spaced out through the four-hour block. This schedule was subject to modification during each sleep period, some recording times being extended when significant changes in sleep could be observed. Only one arrangement of leads was used for the immersion records. It consisted of a bipolar run with eight leads consisting of frontal, central, parietal and temporal, using disc electrodes with bentonite paste.

Changes in psychomotor proficiency were assessed in two ways: (1) three one-hour sessions on complex performance in a simulated systems task, and (2) simpler perceptual-motor tasks performed during immersion. The apparatus used to assess complex performance in a simulated systems task was the Complex Behavior Simulator, a systems simulator developed at the School of Aviation Medicine.<sup>6</sup> This device consists of an assembly of sub-tasks requiring performances ranging from simple functions such as pushing a button when a light flashes to more complex behavior such as decoding multiple signals and integrating them into a single response. Performance on this simulator immediately after the seven-day immersion period and ten days after was compared to baseline values obtained just prior to the hypodynamic period. The apparatus used to assess proficiency changes during immersion contained three separate elements consisting of a binary matching sub-task, a simple vigilance task and a multiple vigilance sub-task. These tasks were operated by micro-switches which, in turn, were activated by a combination of four finger-operated slide controls located on the left arm rest and two hand-operated levers located on the right, as seen in Figure 1. During immersion, the subject performed the tasks continuously for two four-hour work periods each day.

Diet and activity were thus controlled, monitored and tested over a five-week period, includ-

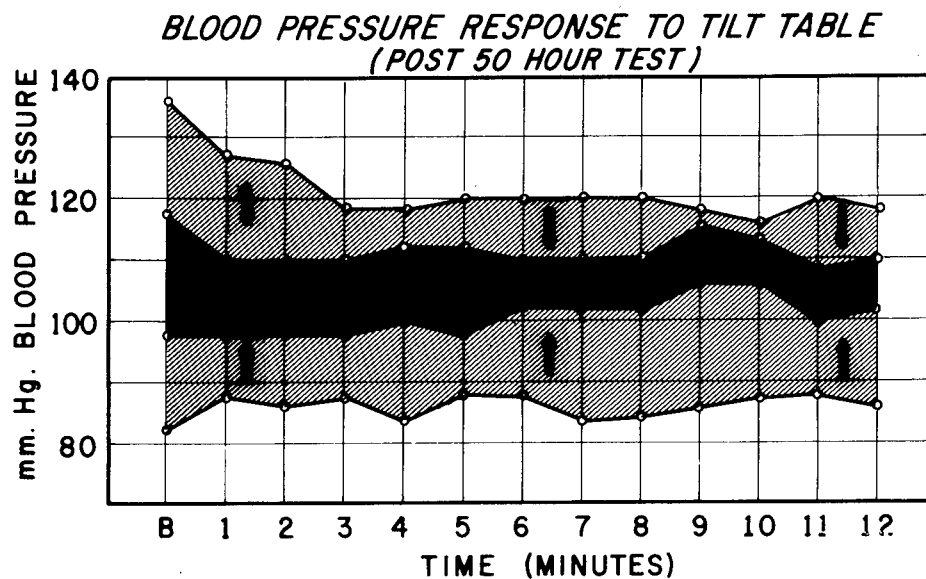


Fig. 2. Blood pressure response to tilt-table testing after the fifty-hour immersion period, demonstrating the decrease from control systolic pressures (top line) and increase over control diastolic pressures (bottom line).

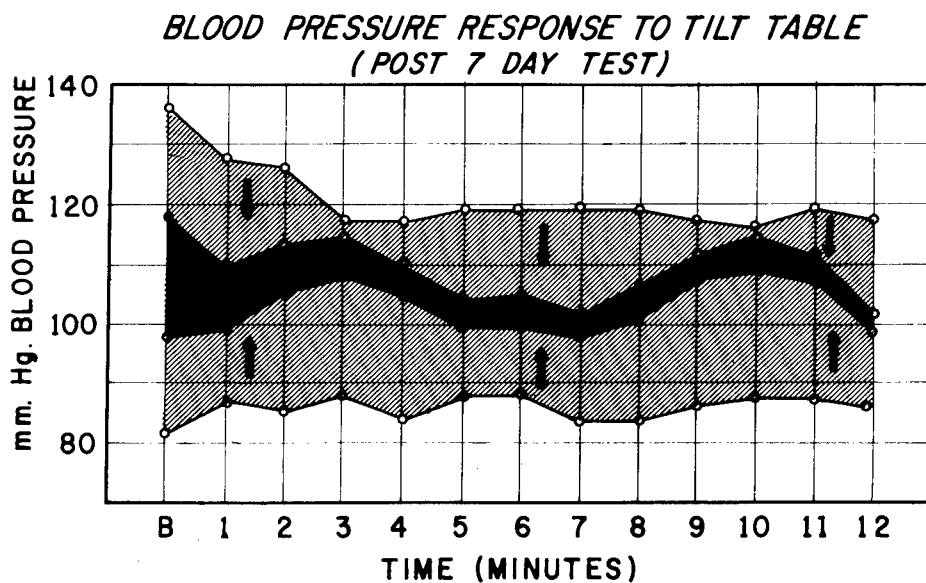


Fig. 3. Blood pressure response to tilt-table testing after the seven-day immersion period, demonstrating the decrease from control systolic pressures (top line) and increase over control diastolic pressures (bottom line).



ing the pilot experiment of fifty hours for equipment checkout and the actual seven-day immersion experiment. During the latter experiment, the subject left the tank only for periods

mersion in the pre-experimental phase, the dietary intake had been in the range of 2,700 calories. The average daily caloric output was determined to be approximately 1,900 calories,

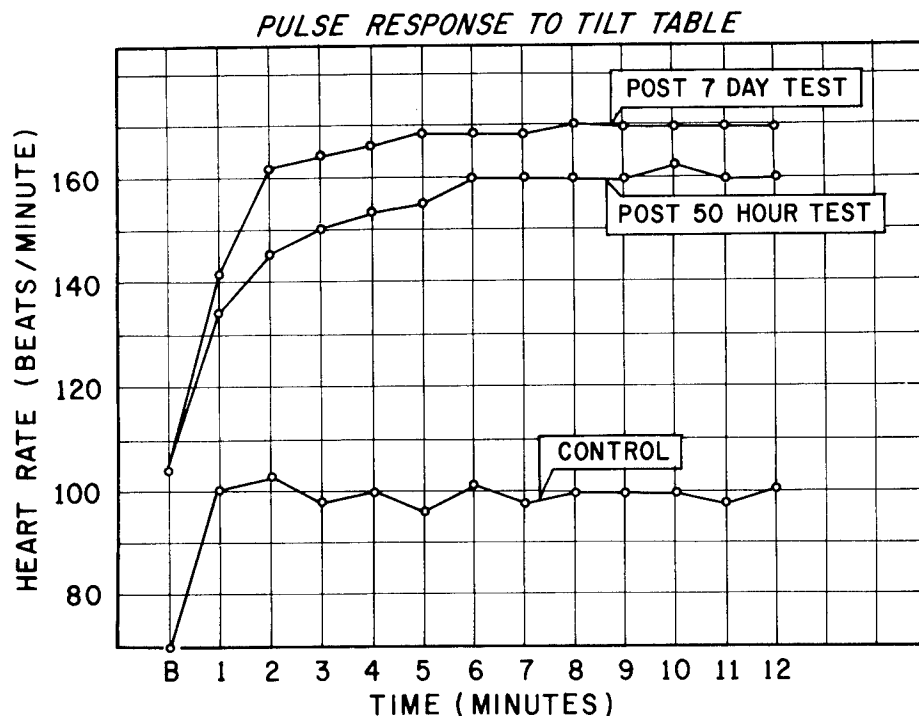


Fig. 4. Heart rate response to tilt table. Baseline rate (B) is obtained while the table is horizontal. The other rates are obtained with the table tilted to 90 degrees.

of about thirty minutes each day for the purpose of skin hygiene, defecation, blood drawing, changing underwear and securing ECG electrodes.

#### RESULTS

*General observations.*—Blood pressure recordings made three times daily revealed that although the pulse pressure stayed relatively constant, a gradual decrease in both systolic and diastolic pressure occurred. The heart rate varied between 68 to 82 beats per minute with no diurnal variations evident. The respiratory rate remained relatively constant at 14 per minute. There were no drastic changes of the metabolic rate related either to diurnal variations or the work-rest periods. During the im-

accordingly the dietary intake was held at this same level. Oral temperatures ranged from 97 to 98 degrees Fahrenheit. A review of the lead II electrocardiographic tracings which were done twice daily throughout the seven-day hypodynamic experiment showed a gradual decrease in the amplitude of the T-waves. This change was most apparent on the fifth test day at which time a plateauing of the T waves was evident with a slight tendency towards notching. By the sixth and seventh days, however, the T-wave amplitude increased somewhat to approximate the initial levels.

*Work capacity.*—A comparison of the pre-immersion and post-immersion response to gradually increased exercise indicated a remarkable

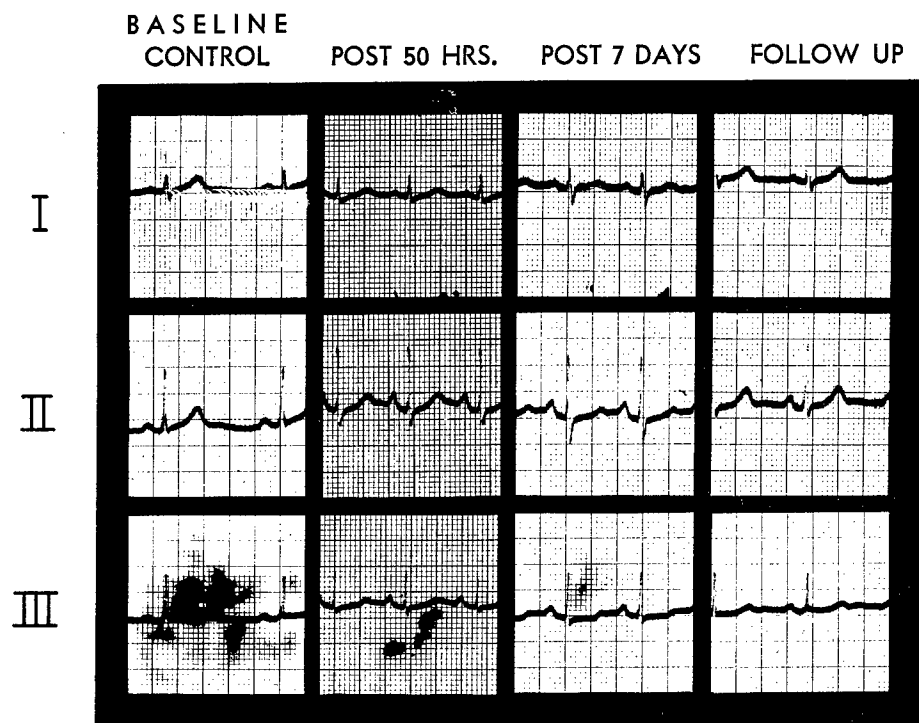


Fig. 5.

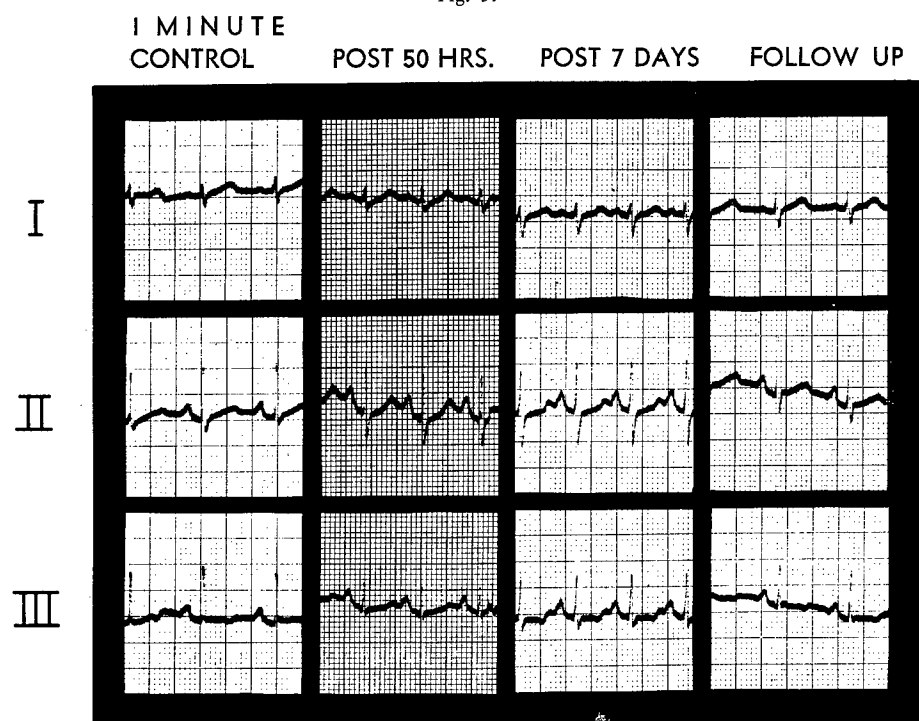


Fig. 6.

Fig. 5 through Fig. 8. ECG leads I, II, and III obtained during the tilt-table testing at baseline (horizontal) and while tilted to 90 degrees at the first, sixth and twelfth minutes. The follow-up

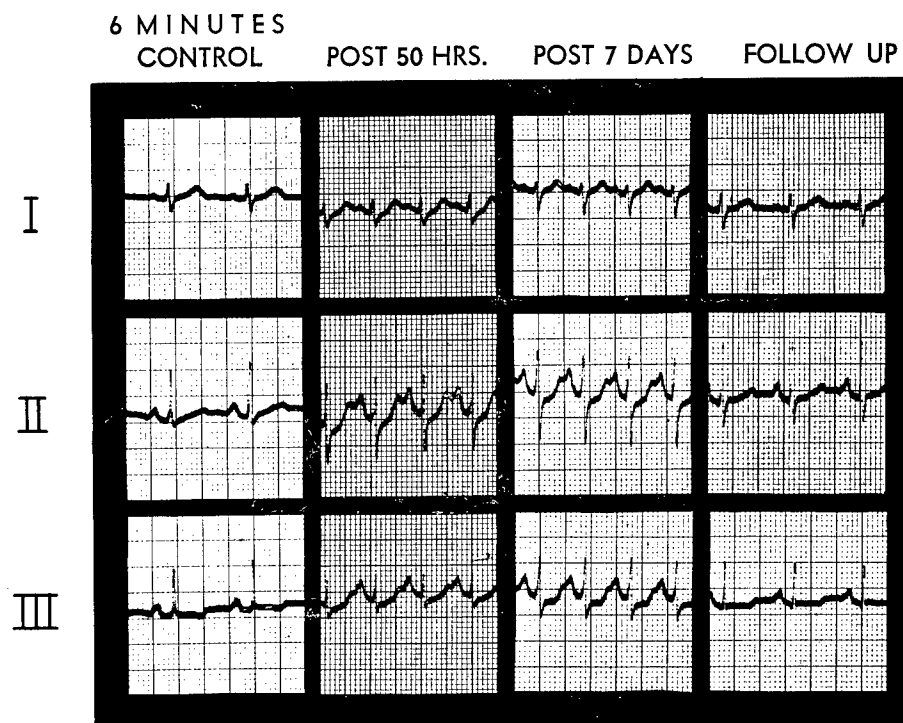


Fig. 7.

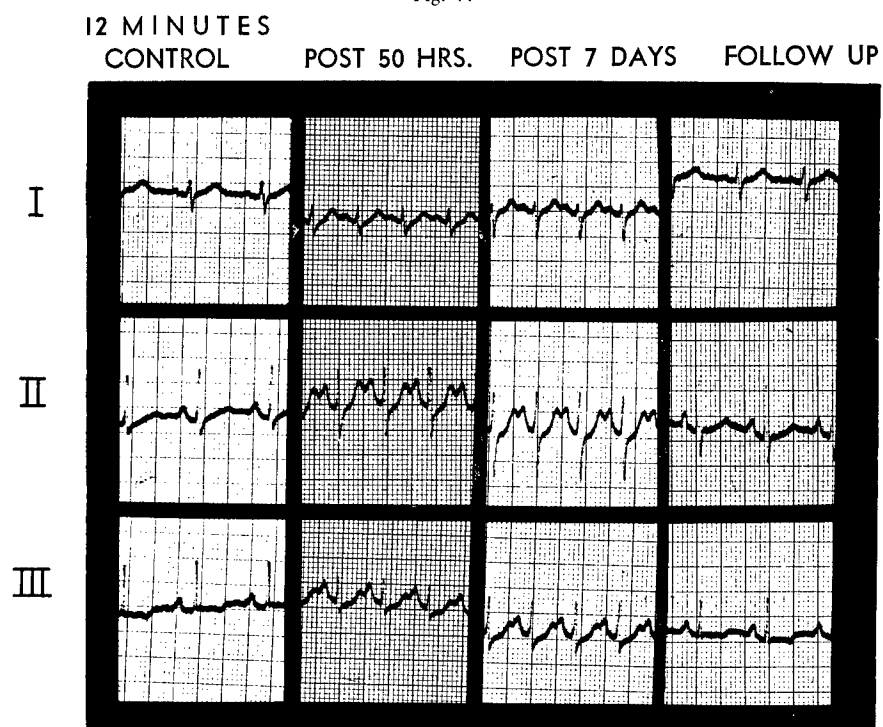


Fig. 8.

test was done ten days after completion of the seven-day hypodynamic period. The heart rate changes, axis shifts and ST, P and T wave changes are well demonstrated.

decrease of functional adaptability. Maximal oxygen intake attained during the control tests on the treadmill was 36.5 ml./kg./min., while after the fifty-hour pilot study, it was 30 ml./kg./min. and only 23.5 ml./kg./min. after the seven-day immersion period. This functional deterioration was revealed by cardiorespiratory patterns typical for physical fatigue: a higher heart rate and reduced pulse pressure at identical work intensities, and by increased frequency and higher minute volumes of ventilation.

*Orthostatic tolerance:*—Blood pressures during the tilt-table studies after both the fifty-hour and the seventh day are shown in Figures 2 and 3. In both instances a decrease in systolic and an increase in diastolic pressures (resulting in a marked decrease of the pulse pressure) were observed. During the control tests on the tilt-table, pulse pressures remained in the area of 35 mm. Hg throughout a twelve-minute period at 90 degrees; however, after the fifty-hour pilot study, pulse pressures were decreased to 10 to 12 mm. Hg and after seven days of immersion, the pulse pressure amplitudes ranged between 4 to 6 mm. Hg in this same position. No syncope occurred during these tests. Following both the fifty-hour and the seven-day hypodynamic runs, tilting to 90 degrees produced a marked pallor of the skin accompanied by a gradually increasing cyanosis. This was not seen during the control studies.

Pulse rate response to the tilt-table tests is shown in Figure 4. The pulse rate changed (after tilting from a horizontal to a vertical position) from 70 to 100 beats per minute during the control tests, from 104 to 160 beats per minute following the fifty-hour immersion, and from 104 to 170 beats per minute following the seven-day study. Resting pulse rate in the supine position on the tilt-table increased from 70 to 104 beats per minute as a consequence of the hypodynamic state induced during water immersion.

Electrocardiographic response to tilt-table tests are shown in Figures 5 to 8. Standard ECG leads I, II, and III, during supine position

and the first, sixth, and twelfth minute with the subject tilted to 90 degrees, showed the following changes:

1. Control ECG showed orthostatic T-wave changes consisting of decreased amplitude, flattening and inversion occurring as a normal variation in a certain percentage of normal healthy people.

2. Following the fifty-hour and the seven-day water immersion experiments, tachycardia, increased amplitude of the P-waves and junctional ST occurred. There were no significant T-wave changes from baseline values. The tendency of the T-waves to decrease in amplitude as noted in the control ECG was no longer apparent. The accentuation of the S-wave reflected a shift of the QRS axis so that the terminal electrical events were directed more toward the right shoulder. The above findings were more prominent following the seven-day test. However, the changes occurring after only fifty hours of immersion were also quite dramatic.

3. Follow-up ECG studies showed a return to normal after ten days.

*G-Tolerance:*—The elapsed time between removal from the water tank and the G-tolerance tests was eleven hours. This time delay was caused by the post-immersion tests and by the subsequent transportation in jet aircraft to the centrifuge test facilities. G-tolerance to both rapid onset of rotation (ROR) and gradual onset of rotation (GOR) were obtained.<sup>3</sup>

Heart rate responses obtained during the centrifuge runs indicated greater cardiovascular stress post-test, however, the G-tolerance as measured by blackout threshold alone was unchanged. Presumably this indicated that mean arterial pressure and sufficient supply of blood to the brain and eyes were still maintained. Subjectively, after the seven-day hypodynamic experiment, G stresses were much more severe, producing greater sensations of pressure, much more discomfort and incapacity, and marked nausea.

# WATER-IMMERSION INDUCED HYPODYNAMICS—GRAVELINE ET AL

**Hematologic Findings:**—The results of the hematologic evaluations before, during and after the seven-day experiment are presented in Table I. Sedimentation rates and white blood cell differentials also were done. These showed no significant changes from control values. As can be seen from the table, the WBC values increased steadily during the test to more than double the control level. The hematocrit showed a maximum increase in the third day to a value of 57. This was confirmed by two repeat tests. At this time, scleral injection and a dusky red color of the face gave clinical evidence of a plethoric condition. Generalized pruritus was

nitrogen excretion before and during the hypodynamic seven-day period were determined by the Micro-Kjeldahl technique and are shown in Figure 9. The marked elevation in urinary

TABLE I. HEMATOLOGIC STUDIES

	RBC	WBC	HCT
CONTROL I	5,390,000	7,250	47
CONTROL II	5,220,000	6,850	44
CONTROL III	5,510,000	6,900	48
DAY 2	5,660,000	9,100	49
DAY 3	6,090,000	9,200	57(56,57)
DAY 4	—	10,550	49
DAY 5	5,220,000	11,200	49
DAY 7	—	15,650	53
FOLLOWUP	—	8,250	44

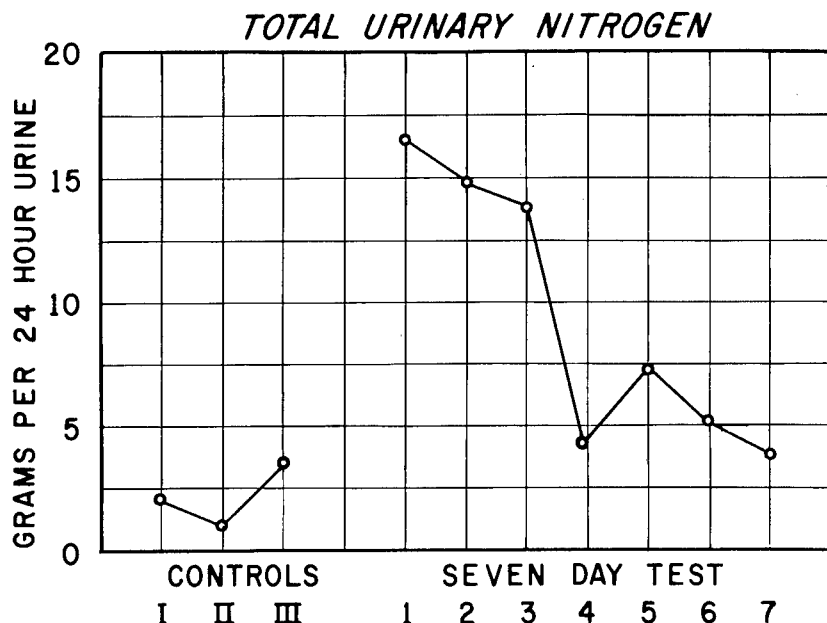


Fig. 9. Total urinary nitrogen excretion during the seven-day hypodynamic period are compared to the control values, demonstrating the marked nitrogen output during the first three days.

also maximal at this time. However, by the beginning of the fourth day this condition diminished markedly. Pruritus became less tense, and the face and sclera assumed a more natural appearance. The hematocrit at this time was 49. Changes in the red blood cell count paralleled the changes in the hematocrit.

**Biochemical Findings:**—Total daily urinary

nitrogen excretion on the first three immersion days corresponded closely to the polyuria noted during this same time. (See Figure 10 for twenty-four-hour urine volumes). Approximately 45 gm. of nitrogen were eliminated during this seventy-two-hour period. During the entire seven days, a total of 66 gm. of nitrogen were eliminated. Control values averaged at 2.3 gm. daily.

Urine volumes for each twenty-four-hour period are shown in Figure 10. Starting about four hours after entering the tank for the seven-day run, there was marked polyuria accompan-

decline to control level. Norepinephrine values, also expressed in gamma per hour, showed a rather marked elevation on the second day, and then also a gradual return to control level.

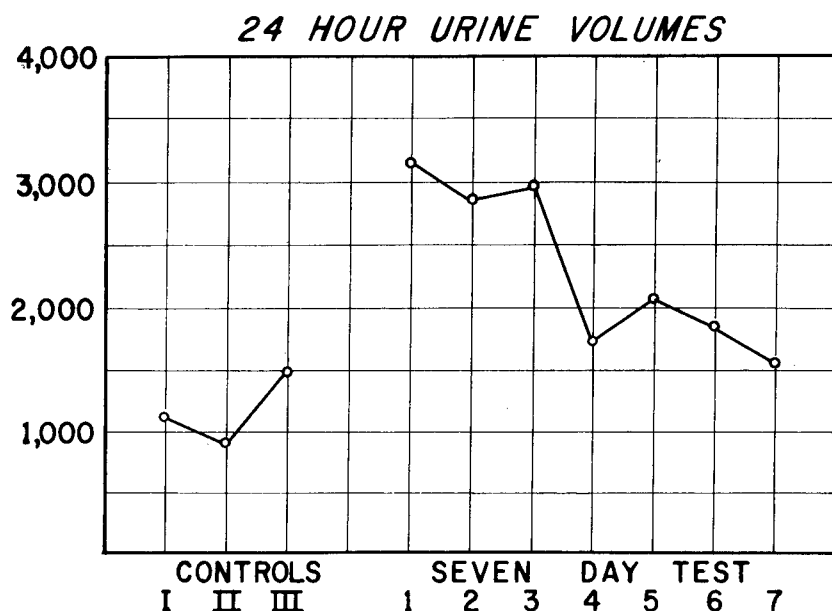


Fig. 10. Twenty-four hour urine volumes, demonstrating the polyuria which was most marked during the initial three days.

TABLE II. BIOCHEMICAL ANALYSIS OF SERUM SAMPLES

	meq/l				mg %		
	Na	K	Ca	Cl	UREA	GLUCOSE	PO <sub>4</sub>
CONTROL (AVERAGE OF THREE VALUES)	141.4	3.7	5.3	102.3	18.6	70	3.1
DAY 1	142.0	4.1	5.5	101.6	18.0	70.8	3.5
DAY 2	141.6	3.9	5.5	102.1	20.0	69.8	4.8
DAY 3	142.6	4.1	5.5	102.8	20.6	63.0	4.6
DAY 5	143.2	3.7	5.4	105.2	20.4	58.0	5.7
DAY 7	142.2	3.5	5.5	101.1	19.5	60.0	4.0

ied by a demanding polydipsia. This persisted for about seventy-two hours and then decreased abruptly. During this phase of water loss the mucous membranes, lips and throat were dry. The clinical evidence of plethora and the increased hematocrit during this time period have already been mentioned.

Urinary catecholamine studies indicated that epinephrine values, expressed in gamma per hour, showed an initial elevation, then a gradual

Plasma-free 17-hydroxycorticosteroid studies indicate that throughout the seven-day immersion period, the values were consistently elevated over the control values, while urine total 17 OH corticosteroid determinations showed no significant changes from baseline levels and apparently did not parallel the serum values.

The results of serum determinations of Na, K, Cl, Ca, PO<sub>4</sub>, urea and glucose are presented in Table II. In each case, three control determinations have been averaged to obtain a baseline value. With the exception of PO<sub>4</sub>, the various biochemical constituents remained remarkably constant throughout the seven-day water immersion test. The PO<sub>4</sub> values increased considerably from a control value of 3.0 mg. per cent to a maximum value of 5.7 mg. per cent on the fifth day.

The results of the urinary determinations of

# WATER-IMMERSION INDUCED HYPODYNAMICS—GRAVELINE ET AL

Na, K, Ca, Cl and  $\text{PO}_4$  were expressed as meg./24 hours and are presented in Table III. The dietary composition throughout the entire four-week control period and during the seven-day test period was constant; however, the actual quantity of the diet was 2,700 Calories daily during the former and 1,900 Calories daily during the latter period. Despite a 30 per cent decrease in intake, urinary output of Ca and  $\text{PO}_4$  showed no significant departure from control figures. This could be interpreted as an indication that liberation of available Ca salts from skeletal sources was occurring due to disuse changes, thus contributing to the total urine output. However, the metabolism of these substances is extremely complex and further investigation is necessary before definitive interpretations can be made. Na and Cl were very similar in their changes during the test period. They showed a rather marked initial outpouring followed by a decrease to below control values on the fourth day and a terminal elevation to control values or greater.

SGO-T determinations throughout the test period showed no significant variation from control values.

## Immunochemical Analysis of Serum Samples:

—Samples were analyzed for total protein, increases or decreases in a reliable nonspecific stress indicator associated with mucoprotein, and changes in the concentrations of albumin, gamma globulin, beta globulin, and alpha glycoproteins. A combination of immunodiffusion and paper electrophoretic methods was used. Statistically significant results at 0.05 level were as follows:

1. A progressive increase in total protein (base 7.11) to a high of 7.82 gm. per cent at seven days.
2. A marked increase in the concentration of serum albumin beginning at twenty-four hours through forty-eight hours, decreasing sharply to base-line at the seventy-two-hour level.
3. A marked increase in gamma globulin concentration beginning at forty-eight hours

through seventy-two hours, then returning precipitously to the normal range for the remainder of the samples.

4. A decrease in the A/G ratio at forty-eight hours to 1.64 from a base-line of 2.18.

TABLE III. BIOCHEMICAL ANALYSIS OF URINE SAMPLES

	(meg/24hrs)		Ca	Cl	$\text{PO}_4$
	Na	K			
CONTROL (AVERAGE OF THREE VALUES)	251.7	81.1	10.8	74.9	49.2
DAY 1	549.5	83.1	11.8	137.1	35.1
DAY 2	345.0	79.4	7.8	77.6	45.1
DAY 3	221.6	103.6	12.9	55.1	61.7
DAY 4	175.7	80.6	7.5	39.2	51.1
DAY 5	131.1	70.6	8.7	43.6	42.3
DAY 6	192.3	74.3	10.4	50.1	45.4
DAY 7	307.5	40.7	10.9	66.7	39.3

Several calibrated reagents were used without success in an attempt to detect concentration increases in a substance associated with mucoprotein. Such increases have been reliable indicators of other aerospace stresses, such as irradiation, long-term altitude chamber exposure and serological imbalances. The results were not so extreme as to suggest harmful experimental conditions, and indicated that the experimental conditions for this subject were not markedly stressing.

*X-Ray Studies:*—Radiographic studies which were done include PA of the carpals and PA and lateral of the tarsals for evidence of bony demineralization. These films were taken before, immediately after, and one week after the seven-day period of water immersion. In reviewing these films, significant bony change could not be demonstrated.

*Psychomotor Performance:*—There was a significant decrement in performance proficiency related to the hypodynamic state. These findings are covered in detail in another paper.<sup>5</sup> Briefly, an analysis of the response times of performance during immersion revealed a significant but small increase on each successive day, indicating a gradual decrease in psychomotor effectiveness. Observations of the subject's performance on the Complex Systems

Simulator immediately after the seven-day hypodynamic period demonstrated gross disruption of psychomotor effectiveness. During the first forty-five minutes after coming out of the tank, the subject was obviously almost nonfunctional. Initially, the subject's performance was characterized by marked disorganization of the psychomotor response pattern with each response clearly fractionated into three segments: detection of the signal, selection of the response, and execution. Detection was accompanied by an exaggerated startle response to signals having high attention value and execution was characterized by gross spatial errors.

*Sleep Studies:*—Sleep in the hypodynamic environment was monitored by means of electroencephalographic recordings and evaluated with pre- and post-immersion control recordings. This part of the study is reported elsewhere.<sup>7</sup> An analysis of these EEG records reveals several important findings. First, the total amount of actual sleep each day was considerably less than the allotted four hours. In general, after the second day the subject slept very little during the fourth hour. Second, the range of sleep states became progressively smaller on each successive day. Third, the amount of variability in relative depth or quality of the sleep state showed a progressive reduction across days, with improved stability in sleep states during the middle portion of the sleep periods during the latter days. There was a progressive adjustment of sleep to the hypodynamic environment during the week, and the most characteristic sleep state during the latter period was one falling between drowsiness and light sleep. On the average, it appears that the subject spent on the order of 120 to 130 minutes in some sort of sleep state each day. Most of the sleep during this period was of a very light to dozing nature from which the subject could be easily aroused. Only rarely did deep sleep occur similar to the control and follow-up sleep records. Yet all evidence indicated that the amount of sleep obtained was entirely adequate under these hypodynamic conditions. The sub-

ject remained normally alert at all times during the seven-day experiment and presented no indication that a sleep deficit was accumulating. Following the experiment, the subject immediately went back to his normal sleep pattern of seven to eight hours daily.

#### DISCUSSION

The results of this study provide evidence that the debilitating effects of a prolonged hypodynamic state are extraordinary, especially with respect to the cardiovascular system. The experiment was essentially an extension of previous bed-rest studies except that the hypodynamic state induced by water immersion was more severe and produced earlier and greater debilitating changes. There is every reason to anticipate that a true weightless condition may produce similar or even more pronounced effects.

Concerning the experimental design, there are obvious sources of bias which must be taken into consideration in the interpretation of the results, aside from its exploratory nature. Allowance must be given to the possible influences of the water pressure on the immersed body of the subject, and to the alteration of normal thermoregulatory dynamics by the elimination of evaporative cooling.

It should be stressed that while the subject was immersed, few of the debilitating effects were apparent. Blood pressure, pulse rate, temperature, and respiration showed no significant departures from normal values. It was only upon removal from the support of the water, and return to a normal gravitational sensation that muscular tone and strength were seriously affected.

A marked deterioration in the mechanisms necessary for adequate circulation in the erect posture was shown by tilt-table testing. A great reduction of the work capacity measured on the treadmill reflects a pronounced decrease in cardiorespiratory adaptability. Centrifuge determination of G-tolerance following the hypodynamic state similarly revealed much greater cardiovascular stress.



In addition to these debilitating changes of a functional nature, interesting metabolic changes occurred. At the present, no definite explanation can be given for the progressive increase in white blood cell count, the rather large increases in total urinary nitrogen, the elevation in hematocrit, or for the immunochemical responses. More experimental work is necessary to substantiate and clarify these results.

Although the psychomotor performance showed a slight, but significant, progressive decrease during the seven-day water immersion, this might only reflect altered states of motivation. There was little reason to expect a major performance decrement during the hypodynamic state, where the over-all functional effectiveness of the subject exhibited so few changes. The real proficiency problem for a man in space flight lies in the gross debility which may result from prolonged hypodynamic conditions. The essential finding of this study was the generalized incapacitation of man upon return to normal 1 G sensation. The sudden impact of returning gravitational forces not only affected physical fitness but also psychomotor effectiveness for a complex systems task. Such reaction to increased G-forces after a longer period of weightlessness might become crucial for the astronaut as he experiences the re-entry phase.

The information obtained concerning sleep was completely unexpected. Evidence indicates that the reduced amount of sleep appeared entirely adequate for the existing conditions. The broader implications of these results may have major theoretic importance. They suggest a specific biologic purpose for sleep. How can we account for the fact that the subject, on less than a third of the normal amount of sleep (and most of it drowsiness or light sleep), gave every indication of having had all the sleep he needed? His sleep during immersion represents a marked deviation from his normal sleep habits, yet there were no observable or subjective signs of sleep deprivation.

Under normal gravitational conditions, a significant portion of the total amount of energy

expended each day is for work done while compensating for gravitational influences. This involves more or less continuous neuromuscular activity which stops only when we stop counteracting gravity in a relative way, as, for example, when we go to bed. It can be postulated that this involves some progressive accumulation of fatigue—some neuromuscular "debt."

In the hypodynamic state, during immersion, there is no need to counteract G-forces. Nor will it be present in the weightless state. Therefore, the magnitude of the neuromuscular "debt" will be greatly reduced, and the duration of the recovery period required will be reduced. In effect then, the duration of sleep needed to maintain normal efficiency will be reduced. The results of this aspect of the study lead to the premise that the biological function of sleep is to provide a period with minimal requirements for counteracting gravity so that recovery from the neuromuscular "debt" accumulating in the active man can take place. Now, sleep is obviously more complicated than this hypothesis suggests, and our hypothesis deals only with the biological purpose, but it would appear that this may be the bedrock of the function of sleep.

If further investigation into this hypodynamic area corroborates these findings concerning sleep, it may mean that the sleep demands of the orbiting astronaut will be significantly reduced. Information of this nature is essential for space operations.

#### SUMMARY

Utilizing a technique involving whole-body immersion in water, a hypodynamic environment was produced in which the normal weight sensations were removed and movement was effortless. This experiment was conducted with one subject for a seven-day period during which time extensive biologic data were collected.

There are definite indications that pronounced functional impairment results from prolonged exposure to hypodynamic conditions. There is

a marked decrease in the need for sleep, and sleep characteristics observed in this quasi-weightless environment permit us to hypothesize a specific biological function for sleep, suggesting that it provides a period of recovery from the neuromuscular "debt" accumulated by man in counteracting the effects of gravity. Following the period of immersion, marked changes of cardiovascular reflexes and diminished muscular tone were apparent. Hematologic investigations and extensive biochemical studies on blood and urine show some interesting changes, and there is a gross disruption of psychomotor effectiveness. In general, this study suggests that during prolonged space flight under true weightless conditions the organism may attain a critical state of deconditioning which will seriously attenuate his tolerance for re-entry stresses and the normal gravitational environment. Investigation into this area must continue in an effort to further assess these effects, and then to develop appropriate protective devices or techniques.

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### Kinsey's Heritage

After a few uncertain years following the death of Dr. Alfred C. Kinsey in 1956, the Institute for Sex Research at Indiana University in Bloomington is in the midst of vigorous activity. Nate Haseltine, *Washington Post* and *Times-Herald* science writer, recently visited the Institute and reports that the staff is engaged in an intensive study of some 600 convicted sex offenders. A book on pregnancy, birth, and abortion has been published. The Institute's collection of material continues to expand and includes 23,000 books, between 30,000 and 40,000 art prints, 18,000 case histories, and films on mammalian sexual behavior as well as lewd movies produced during the past generation. To the University's maintenance support, the National Institute of Mental Health has added \$350,000 in grants since 1957.—*Modern Medicine*, March, 1961.

# Medical Support of ICBM Operations

BRIGADIER GENERAL THEODORE C. BEDWELL, JR., USAF, MC,  
COLONEL ALVIN F. MEYER, JR., USAF, MSC and  
LIEUTENANT COLONEL GEORGE R. ANDERSON, USAF, MC

**T**HE RAPID DEVELOPMENT of an operational strategic missile capability has resulted in a number of special needs insofar as medical support is concerned. Because of the nature of the weapon systems involved, military commanders and staff agencies have been even more acutely aware than is the normal case of the need for consideration of health protection and health promotion in human economy considerations for the missile program.

Before entering into a discussion of details of medical support, the basic medical mission in an operational command such as the Strategic Air Command (SAC) should be restated. Briefly, it is to furnish the medical support to maintain the highest possible degree of combat readiness and effectiveness of the command. In order to attain this mission, the traditional underlying procedures of military medicine similar to those of the specialized areas of aviation medicine, occupational medicine, and preventive medicine must be applied. These include: techniques for selection of personnel, both prior to entry into the assignment, periodically thereafter, and for separation; diagnosis and treatment of both occupational and nonoccupational diseases; and preventive measures regarding the environment and the individual.

The actual medical support of both missiles and manned weapon systems in Strategic Air Command consists of activities which can be divided into three broad areas: Community

medicine involves the routine health maintenance of military personnel and their dependents, the care and treatment of the morbid conditions associated with normal living activities, and the related general public health functions necessary to provide a healthy environment. Mission medicine is the second area and consists of all those activities directly associated with operations. In Strategic Air Command, we have for several years combined the functions of preventive medicine, aviation medicine, and occupational medicine into a single functional entity now designated as the Aerospace Medicine Program. This program concerns itself with the specialized health maintenance activities directly associated with weapon systems including their operation and maintenance. The third area is Disaster Control. All of the personnel of the medical service, be they assigned primarily to community or mission medicine activities, are combined to meet the problems of disaster control. This capability must be constantly ready to cope with the situations arising from a peace time disaster or war operations.

The number of intercontinental ballistic missiles (ICBM) coming into the SAC inventory will gradually increase. The Atlas is operational on a limited basis. The Titan is scheduled for the immediate future with the Minuteman entering into the program a bit later. In general, our ICBM medical support plans follow the operational and logistic concepts for the missile systems. It would be impractical and inefficient as well as uneconomical to attempt to develop a medical support plan which did not conform to the general procedures utilized for the overall weapon systems operational support period. The

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General Bedwell is Commander, USAF Aerospace Medical Center, Brooks AFB, Texas. Colonels Meyer and Anderson are in the Office of the Surgeon, Hq. Strategic Air Command, Offutt AFB, Nebraska.

Presented at the Aerospace Medical Association meeting, May 11, 1960, in Miami, Florida.

ICBM medical support plans have been incorporated into the command plans as an essential component thereof.

We have had to take into consideration the

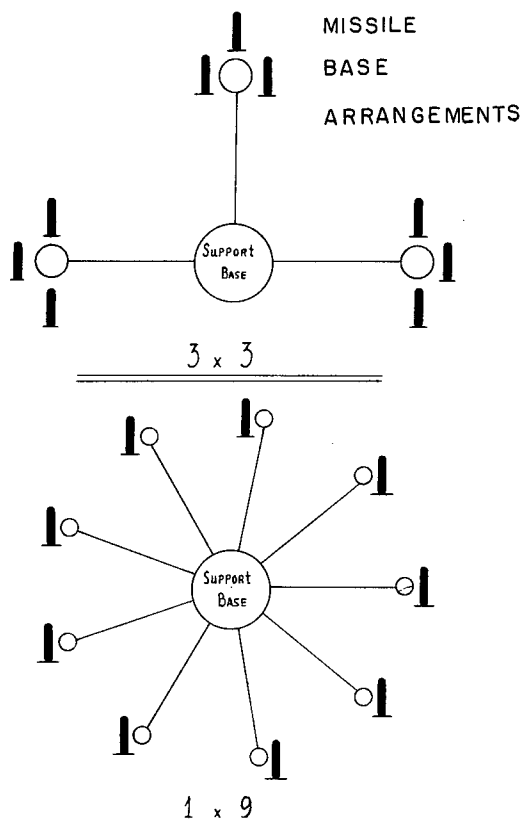


Fig. 1. The missile base arrangements to show placement of support base and launch pads in the 3 by 3 and the 1 by 9 versions of a missile complex.

economy of effort versus idealistic support requirements. While it might be desirable to provide a complete self-contained small medical treatment facility staffed around the clock by independent duty technicians at each missile launch complex, analysis of both the potential hazards involved and the operational situation (as contrasted with research, test, or training situation), the manpower costs, and medical training requirements, early indicated that the doubtful benefits received would not demand

the expenditure for both the facility and the personnel. A brief discussion about the missiles, the support base operations, and the launch complexes, will permit a better understanding of the medical support requirements and the procedures which will be followed in the Strategic Air Command to provide same.

SAC missile complexes consist of a support base surrounded at varying distances by missile launch sites. Early versions consist of what are known as the 3 by 3 type complexes. This arrangement provides for three block houses at distances of 18 to 20 miles from the support base with three launchers at each block house area. Later versions are in the 1 by 9 configuration where individual missiles with a simple launch control center are dispersed at distances of 18 to perhaps 50 miles from the support base (Fig. 1).

The Atlas which has sometimes been unofficially designated as the work horse of the missile force because of its role in Aerospace Research work as well as a component of the missile arsenal is the first operational ICBM (Fig. 2). It is a stage and one-half missile and uses liquid oxygen and a hydrocarbon fuel as propellants. This missile is approximately 82.5 feet in length with a body diameter of about 10 feet. At launch, it weighs more than 250,000 pounds.

The Titan is a two-stage ICBM. As in the case of the Atlas, it is a liquid propellant missile utilizing liquid oxygen and RP-4, a petroleum hydrocarbon. While some of the later Atlas sites will be semihardened or hardened, all Titan installations will be hardened to withstand 100 pound per square inch pressures. This underground environment presents certain specific health maintenance and protection problems including those relating to noise, vision, and maintenance of suitable thermal and atmospheric quality.

Minuteman is a three-stage, solid-propellant intercontinental missile. It is smaller and lighter than the liquid fuel Atlas and Titan. The simplicity of storage and maintenance allows the Minuteman to be more easily hardened. Minuteman installations will be scattered in widely-

dispersed locations in hardened configurations. In addition, as has been recently announced, a portion of the Minuteman force will be operated in a mobile configuration utilizing railroad trains. Extensive studies have been made by the medical service of the Strategic Air Command working in conjunction with Air Research and Development Command and medical service agencies to evaluate the many problems of health protection and health maintenance involved in this unusual activity in the field of aerospace. Surprisingly enough, while there is a wealth of information on routine railroad operations, there is very little information regarding the problems of living aboard trains for prolonged periods of time. Special consideration is being given to problems of waste disposal, water supply, bathing and laundry, and even means of providing medical support to small numbers of personnel in a widely-dispersed mobile situation.

Among the areas of concern from a health viewpoint at the support base are the missile assembly building, squadron maintenance areas, and the liquid oxygen and liquid nitrogen generating plants. In addition, there must be the usual environmental health and over-all preventive medical considerations for housing areas and other personnel support facilities. The missile assembly building and strategic missile assembly shops include such activities as painting, welding, metal-working, battery charging, engine repair, liquid oxygen cleaning, and guidance system checkouts. Each of these involves a potential exposure to toxic agents. The usual hydrocarbon solvents also are widely used in missile maintenance. In addition, there are a number of painting and solvent cleaning operations requiring industrial hygiene surveillance. Inherent in any weapon systems activity is the necessity for concern for peace time nuclear disasters; therefore, a need exists for personnel who are specially trained in health physics. The propellant storage area at an operational base has been the subject of considerable preventive design measures. These include an adequate water supply to insure that fire protection or firefighting can be achieved effectively.

Showers and eye baths are furnished to take care of the possibility of a spill or pressure line failure. Propellant handlers are required to wear protective clothing and the buddy system

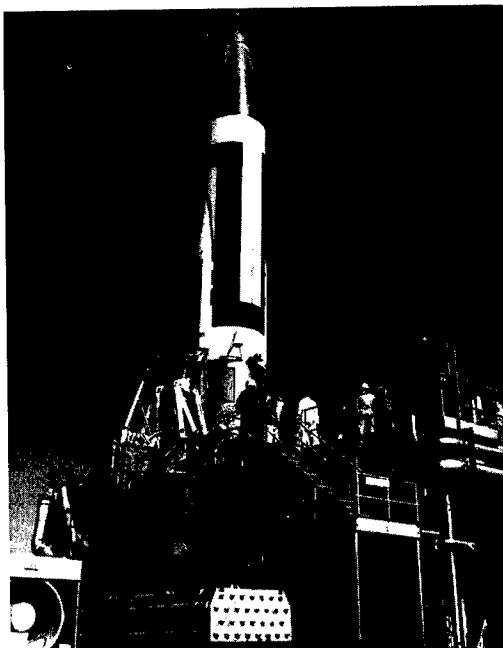


Fig. 2. This Atlas Missile is being prepared for launch by SAC training crews at Vandenberg AFB. Liquids under high pressure, potentially toxic chemicals, and adverse physical environmental situations require preventive considerations as part of the system. Protective devices such as hard hats and special clothing are necessary for some workers as shown. Emergency showers and eye baths will be noted on the launch platform (center right of photo). Warning horn to alert personnel of potential hazards is seen in the lower left.

or two-man team approach is used. The usual other protective measures, such as fire blankets, static grounding, and so on, are provided in these areas. In the Air Force Weapons Supply and Strategic Missile Assembly Supply Areas, some special radiologic health problems exist with regard to static eliminator bars and the radioactive electronic tubes.

At the launch emplacement, one finds the launch pad, propellant, and oxidizer storage tanks, piping and valve complexes to connect these storage tanks with the missile, the guid-

ance antenna, and a control center. Among the problems which may be experienced at an operational launch emplacement are those associated with unit simulated missions including

materials having toxic properties also present special concern. In SAC, we are already familiar with handling large volumes of such materials as JP-1 and ammonia. We have learned as in

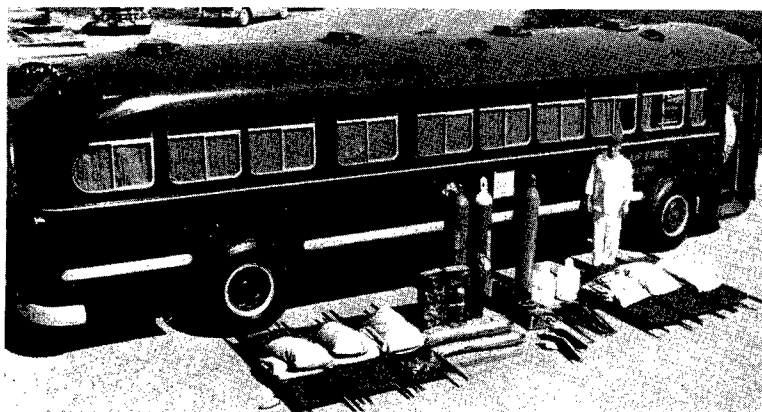


Fig. 3. Missile Accident Medical Support. A bus type ambulance has been developed at Vandenberg AFB for use in support of Disaster Control requirement, because of the specialized training operations at Vandenberg. Such extensive equipment will not be necessary at the majority of SAC Missile Bases. Standard ambulances augmented by a Disaster Trailer will be used.

propellant loadings and followed by de-fuelings, erection of the missile and its subsequent lowering, removal of missile components from the missile for return to the base shops for repair or maintenance, mating and de-mating of missiles with the launcher, and the possibility of high pressure leaks. Since missiles will not be fired from operational locations except in case of war, many of the problems associated with research and development and training launch centers will not be present. On the other hand, a wide variety of potential physical stresses as well as chemical exposures does exist.

Among the unique problem areas for both the present and the future are those relating to the so-called "exotic" propellants which are being considered for future missiles. One can envision the possibility of storage and handling of large quantities of such materials as unsymmetrical dimethylhydrazine which is already used in certain of the present missile applications. Large quantities of commonly utilized

industry that a dangerous material can be handled safely provided adequate surveillance and health precautions are followed.

While missile dispersal complicates the enemy's target problem, the remote locations produce some possible adverse effects due to boredom, fatigue, and psychological adaptation—all of which create a requirement for human engineering activity in the development of the designs for the remote facilities. The medical service has participated in the past in development of these requirements and will continue to do so in SAC.

Having described somewhat the missile operational complex and some of the problems associated therewith, the medical support procedures in SAC to provide for personnel assigned these organizations will be described. The preventive medicine and occupational health program is similar to that of a large chemical industry. This phase of aerospace medicine will be provided by the aerospace medicine person-

nel at the support base. Outpatient and inpatient care for missile personnel and their dependents will be provided at the established medical facility at the support base. First aid

Our occupational program is considered to be preventive in nature rather than simply concerning itself with taking care of those who may become exposed as part of their occupational

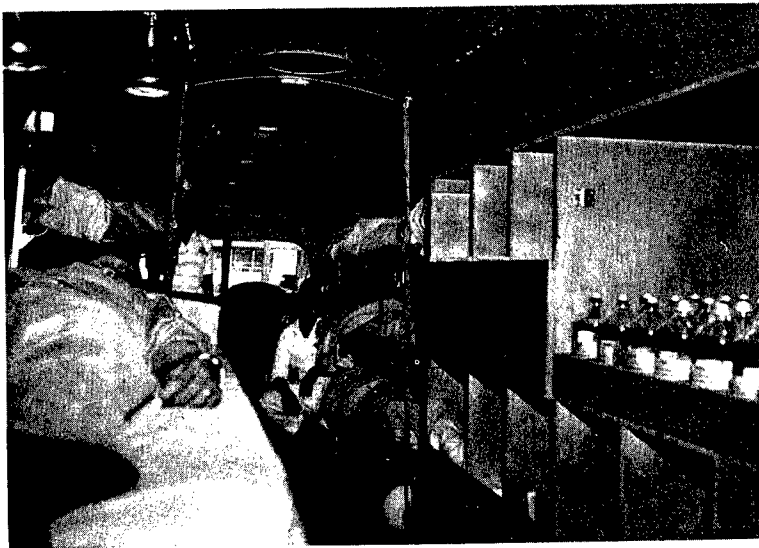


Fig. 4. The interior of the Vandenberg AFB bus type ambulance.

supplies including Phase I Medical Materiel Program for Nuclear Casualty Kits will be at the dispersed sites. All missile personnel will be given an expanded program in self aid and first aid. In the event of a major accident, a light aircraft, helicopter or ambulance will be utilized to take medical teams from the support base to the site and to evacuate casualties to the hospital. Medical planning requires that each missile support base have, on call, necessary teams to meet such an emergency. This is part of our disaster control program, established by appropriate regulation. Missile accident response is a part of the well-developed and established disaster control program (Fig. 3 and Fig. 4). It is contemplated that periodic visits will be made by the chief of aerospace medicine, the sanitary and industrial hygiene engineer, preventive medicine technicians, and veterinary personnel to the launch sites as well as the on-base activities.

environment. In general, at a missile site, we follow the established procedures of occupational medicine by finding the answers to the questions: *Is man all right?* and *How do we keep him that way?* The first involves pre-employment and pre-placement physical examinations to insure the right man on the right job. Also, the development of physical profiles before exposure enables us to detect by subsequent examinations, any subtle changes in physical capability which might be the result of the job environment. To maintain health, continued surveillance over both man and the environment is required and an attempt to educate each potentially exposed person to the hazards of the job and means of combating job stresses. Through industrial hygiene engineering, both in preliminary design before construction of facilities and in surveillance activities afterwards, we seek to control, to the extent practicable and economical, the potential adverse environmental conditions.

There is a relationship between community medicine and occupational medicine. Any of the indicators such as anorexia, headache, digestive disturbances, and so on, which are detected as a part of routine occupational health examinations or in visits to Air Force clinics must be thoroughly investigated to determine whether or not they are the result of an unsuspected exposure in a working environment. The Air Force clinic which is the hard core of our community medical service must be prepared to make special systematic checks in those areas which might reveal the presence of abnormal job exposures.

In the field of environmental protection and nuclear technology, which will be of increasing importance in the aerospace age, it is essential that the engineers of the medical service review criteria and assist in their preparation for missile facilities and other requirements for protective considerations in aerospace activities. A very special problem with regard to disaster control procedures, as indicated before, exists in missile operations because of the large quantities of potentially explosive or flammable materials present. Since these materials also possess hazardous characteristics, the importance of protection of those involved in response to an accident becomes obvious.

While there are many problems still facing us in the total field of aerospace medicine, in the missile operations the solutions require the application of present skills and techniques to

new problems rather than the development of a whole new variety of capabilities.

Progressive medical service participation, both in planning stages and actual operations, is necessary to meet the requirements of maintenance of the human side of the weapon systems. Specialized training for medical officers, engineers, veterinarians, scientists, and support personnel to meet these new challenges and to expand their capabilities is an important aspect of our present program.

Although there are some unique problems associated with missile weapon systems, experience of the Air Force in the Strategic Air Command indicates that dedicated men can safely handle any weapons system. To date, the only condition that has required treatment has been the usual traumatic type industrial injury.

In the missile field there are medical solutions for operational problems through close and continuous cooperation, thorough and frequent indoctrination of missile personnel, and last, but not least, the practical application of clinical and occupational medicine principles.

The mission of SAC involves the prevention of a war. Strategic aerospace deterrence requires an integrated total medical support. We envision the need for possible changes in some of our presently established concepts of both community and aerospace mission medicine as more experience is gained in this new and rapidly expanding field.

### Safety of Fluoridation

"No deleterious action on the thyroid need be feared from the daily dose of 1 mg. fluorine advocated as a prophylaxis against caries," according to K. Hennig and H. Fritz (*Schweiz. med. Wschr.*, 1961, 91, 79). This conclusion is based upon their findings in 26 men who had been working on an average for twenty years in a factory handling fluorine. Some of them already had mild or severe skeletal changes due to fluorine, but all tests of thyroid function—serum cholesterol, basal metabolic rate, and radioiodine uptake—were normal.—*The Practitioner*, March, 1961.



## Response of the Human Retinal Vessels to Positive Pressure Breathing

FLIGHT LIEUTENANT I. D. GREEN, R.A.F.

**O**NE SYSTEM currently used in the Royal Air Force to protect aircrew in the event of their being exposed to altitudes above 40,000 feet employs an oronasal mask. Oxygen can be delivered into such a mask at pressures of up to 60 mm. Hg. Under certain experimental conditions pressures of 70 to 80 mm. Hg. may be delivered to the respiratory tract by this means. There is no provision for applying counterpressure to the rest of the head with this system and in particular the eyes remain unsupported.

When the pressure within the respiratory tract is raised, the central venous pressure increases simultaneously and almost to the same extent. Subsequently, the pressure in the peripheral veins rises until it equals the central venous pressure (Fig. 1). The rate at which this last increase occurs varies in different parts of the body. In an antecubital vein for example, it takes fifteen to twenty seconds; in the central forehead vein which communicates with the ophthalmic vein, the rise is very much more rapid and takes just less than five seconds (Fig. 2). The ophthalmic vein communicates with the internal jugular vein by way of the cavernous and inferior petrosal sinuses. It has been shown that pressure changes in the right atrium are almost instantaneously reflected in the superior bulb of the internal jugular vein<sup>3</sup> so it may be that an increase in the central venous pressure is communicated to the ophthalmic veins and hence to the intra-ocular veins in less than the suggested five seconds. If the envelope of the eye behaved as a rigid box these pressure changes in the intra-ocular vessels would cause a similar instantaneous rise in intra-ocular pressure. However, the cornea and sclera possess a definite distensibility. The possibility arises,

therefore, that if the distensibility of the cornea and sclera is sufficient, over-distention of the intra-ocular vessels may occur and so cause them to rupture, resulting in intra-ocular hemorrhage.



Fig. 1. Subject breathing air under 60 mm. Hg pressure. The suffusion of the face and distention of the veins are apparent.

There would seem to be very little direct information available relating the dangers of intra-ocular hemorrhage to a rapid rise in venous pressure. Some information has been gained from experiments on animals and men subjected to accelerations acting in a foot to head direction (negative acceleration). Henry<sup>2</sup> described experiments on goats exposed to values of up to 15 g. Values of 2.5 negative g for more than fifteen seconds, which caused a rise of 70 to 80 mm. Hg in the pressure in the head veins in two to three seconds, invariably produced con-

# POSITIVE PRESSURE BREATHING—GREEN

junctival hemorrhages. At levels greater than 10 negative g occasional hemorrhage into the anterior chamber of the eye occurred. Other instances of intra-ocular hemorrhage were not

pressure breathing hemorrhage is possible, especially perhaps in the presence of hypoxia or of congenital or acquired lesions of the eye, or as is sometimes the case when an experi-

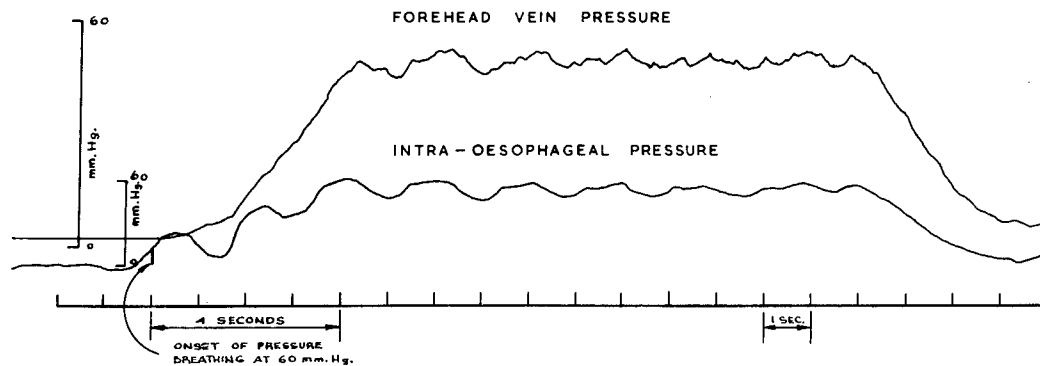


Fig. 2. Relationship between forehead vein pressure and intra-esophageal pressure.

recorded. Henry concluded that the pressure differential between intravascular pressure and ambient should not exceed 50 to 100 mm. Hg, the incidence of conjunctival hemorrhage being very high above 70 mm. Hg.

There are numerous records of conjunctival hemorrhage and a few accounts of anterior chamber hemorrhage occurring in man following accidental exposure to negative acceleration (Fig. 3). In one incident, an observer of an aircraft was subjected to what was estimated to be  $-3g$  following an outside loop. Clinical examination immediately after descent showed extensive sub-conjunctival hemorrhage, exophthalmos and swelling of the lids with effusion of blood, together with pin point hemorrhages in both retinæ. It would seem reasonable to argue that similar changes might be expected in subjects whose intravascular pressure is raised by positive pressure breathing. There have been very few reports, however, of intra-ocular hemorrhage as a result of pressure breathing. This may be because the build-up in venous pressure is slower than in negative acceleration experiments and because breathing pressures rarely exceed 70 mm. Hg unless there is counterpressure to the eyes. Nevertheless, if at any time the intra-ocular vessels are unsupported during

mental subject has been heparinized. It was, therefore, the purpose of the experiments described below to determine whether or not such a state of affairs exists.

Ideally, in order to show that the rise in intra-ocular pressure keeps pace with the rise in intra-ocular vascular pressure during pressure breathing, the intravascular and intra-ocular pressures should be measured simultaneously by direct manometry. In man, it is not justifiable to canulate the eye and the use of non-primate animals for experimental subjects is precluded because of the dis-similarity between the anatomical arrangement of the anterior chamber of the eyes of primates and non-primates. The other recognized method, tonometry, has its disadvantages in that calibration of the method is difficult and frequency responses too low. The method employed in these experiments was based on the assumption that if the vessels of the retina were unsupported during the rise in intra-ocular pressure then their diameter would be increased.

## EXPERIMENTAL METHODS

Kodachrome colour transparencies of the retina were taken with a Zeiss retinal camera. The subject's pupil was first dilated with homa-

tropine. He was seated at the instrument and asked to bite on a fixed mouthpiece, through which air under increased pressure could be administered. His head was held rigidly in position with the aid of a strap around the back of the head attached to the forehead rest. The rigid mouthpiece also aided fixation of the head. No counterpressure to the trunk was employed (Fig. 4). Photographs were taken alternately at rest and at varying intervals, usually at about five seconds and forty seconds, after the onset of pressure breathing at 60 mm. Hg and on a few occasions at 75 mm. Hg. Once the ap-

diameter of the largest vessels was between 5 mm. and 8 mm. and the disc diameter roughly 9 cm. Easily recognizable points on both veins and arteries were selected and measurements



Fig. 3. Subconjunctival hemorrhage after exposure to negative acceleration.

paratus had been set up for the first picture in each series, no further adjustments were made. Any photographs not sharply in focus or any that had been taken after the subject had moved, were discarded. The diameters of the retinal vessels in the control and experimental periods were measured and compared.

Various methods of measuring the images of the retinal vessels were tried, including the use of a travelling microscope and a travelling telescope. The method found to be most satisfactory from the point of view of accuracy and ease was the projection of the transparencies on to a glass screen from a fixed projector, so that the

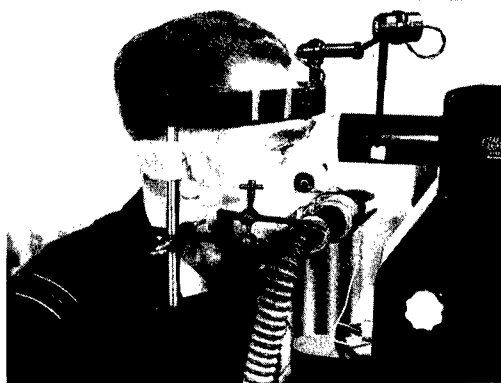


Fig. 4. Subject seated at retinal camera showing method of fixation of the head.

of vessel diameters made with a pair of dividers. Three separate readings were taken on each selected portion of the vessel and four separate vessels were measured in each photograph. It was found that the standard error of the mean of three readings was  $\pm 0.06$  mm. in 5.72 mm.

## RESULTS

A number of independent observers, all reasonably familiar with ophthalmoscopy, agreed that there was no consistent gross change in the appearance of the fundus during positive pressure breathing, and in particular no evidence of intra-ocular hemorrhage (Fig. 5).

The results obtained by measurement of the vessels were arranged together in three groups, namely, those taken at rest, those between zero and ten seconds after the onset of pressure breathing at 60 mm. Hg and those taken after thirty seconds.

In all, 450 measurements of vessel diameter were made from the retinal photographs of six subjects. In the statistical analysis, however, only 200 readings obtained from three subjects were used, these being taken from the technically most satisfactory transparencies.

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The measurements obtained from the images on the ground glass screen could not be translated accurately into the true vessel diameters. For convenience, therefore, the changes in

being significant at the 1:100 probability level. Comparison of the mean diameters of the veins during the first ten seconds and after thirty seconds of positive pressure breathing showed a decrease of 5.2 per cent ( $P=0.001$ ).

There was no difference in the means of the diameters of the arteries in either of the pressure breathing groups when compared with those at rest.

## DISCUSSION

The results obtained demonstrate that during the early stages of positive pressure breathing when the intravascular pressure first reaches its maximum there is no significant distention of the veins of the retina. After the pressure breathing has taken place for thirty seconds or more, however, there is a reduction in the diameter of the veins.

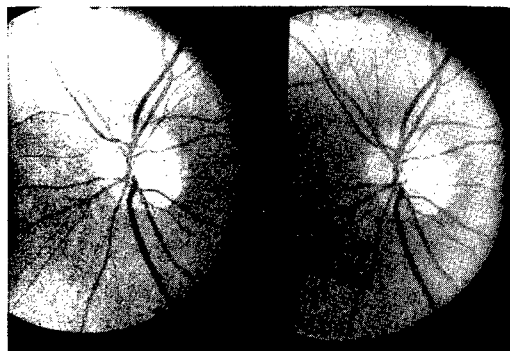


Fig. 5. Positive prints of subject's fundus taken at rest and after six seconds of pressure breathing at 60 mm. Hg.

TABLE I. CHANGES IN DIAMETER OF RETINAL VEINS BEFORE AND DURING POSITIVE PRESSURE BREATHING AT 60 MM. HG.

	Arbitrary Units	Mean Diameters Expressed as Percentage of Resting Value	Per Cent Difference
At rest	5.375	100	2.1 NS
Early period of pressure breathing (0-10 secs.)	5.486	102.1	3.1**
Late period of pressure breathing (after 30 secs.)	5.209	96.9	5.2***

To show mean differences of vein diameters during the three experimental periods.

NS—Not significant      \*\*    \*\*\*—degrees of significance

diameter have been expressed as percentages of the mean resting vessel diameter.

The analysis of measurements of veins showed that the mean difference between the diameters at rest and during the first ten seconds of positive pressure breathing at 60 mm.Hg was 2.1 per cent (Table I). This was not significantly different from zero. There was a decrease of 3.1 per cent in the mean diameter of the veins after thirty seconds of pressure breathing when compared with the resting mean, this

The interpretation of these findings may be facilitated by considering a fluid filled system consisting of a rigid outer container with a distensible bladder within it, comparable to the tube and outer cover of a bicycle tire filled with water. With such a system, if there is any increase in pressure within the distensible bladder, this will be transmitted immediately by the incompressible fluid to the inner side of the rigid container and a pressure difference will not develop across the distensible bladder wall but will

## POSITIVE PRESSURE BREATHING—GREEN

occur across the outer indistensible wall. No change in volume of the bladder will occur. If the outer covering has some slight distensibility, then the extent to which the bladder will distend with a given rise in pressure will depend upon the degree of this distensibility relative to that of the bladder. If the eye is now compared with this system, the sclera and cornea may be likened to the relatively indistensible outer covering. Thus, any increase in the vessel diameter must be accompanied by some distention of the outer coat of the eye. It may then be argued that as no significant increase in the diameter of the veins occurred during the first ten seconds of pressure breathing when the pressure in the vascular bed first reached its peak, there could have been no significant distention of the outer coats. It follows, therefore, that the outer coats of the eye are sufficiently indistensible to prevent rupture of the intra-ocular veins when they are subjected to a pressure increase of up to 60 mm.Hg.

Measurements have been made in comparatively large vessels, though hemorrhage, if it should occur would probably result from rupture of the thin-walled capillaries. There is no reason to suppose, however, that the capillaries are any less protected than the veins. Also as the veins are more distensible than the capillaries if any change had occurred, it would have been seen first in the veins. It may be concluded from these experiments that there is little danger of intra-ocular hemorrhage occurring during posi-

tive pressure breathing of up to 60 mm.Hg when there is no external counterpressure to the eyes.

The venous constriction that has been demonstrated in the retinal veins after thirty seconds of positive pressure breathing may be similar to that which Ernsting found on studying the effects of raising the intrapulmonary pressure upon the capacity vessels of the upper limb.<sup>1</sup> He showed that there was a constriction of the forearm veins under these circumstances.

### SUMMARY

Photographs of the human retinal vessels have been taken during positive pressure breathing at a pressure of 60 mm.Hg without counterpressure to the eyes, and examined. Evidence is put forward to suggest that under these circumstances there is little likelihood of intra-ocular hemorrhage, the intra-ocular vessels being adequately supported by the accompanying increase in tension of the intra-ocular fluid.

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2. HENRY, J. P.: Studies of the Physiology of Negative Acceleration, 1950. USAF Tech. Rep. No. 5953.
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## Cost of Living Down, Medical Costs Up

While the over-all cost of living fell a tenth of a per cent in January, the medical care index rose 0.3 per cent, the Labor Department reported. The increase was largely due to higher rates for health insurance and hospital rooms. Despite the January decline, the first in a year, the cost of living index is 127.4, or 1.6 per cent above a year ago.—*Modern Medicine*, March, 1961.

# Theoretical Prediction of the Effect of Rate-of-Onset on Man's G-Tolerance

M. KORNHAUSER

MAN'S TOLERANCE to acceleration or deceleration has been studied extensively with the purpose of isolating parameters such as body position, direction of acceleration, duration of acceleration, rate-of-onset of acceleration, et cetera. Although some of these parameters have been evaluated in a reasonably unequivocal fashion, a clear understanding has not been developed of the relative roles of peak acceleration, duration, and rate-of-onset. It is the purpose of this paper to elucidate the effects of these factors on man's G-tolerance through analogy with the response characteristics of a theoretical, linear model.

A similar approach was adopted in order to extend man's tolerance data into the region of short duration impact.<sup>5</sup> The model appeared to fit the experimental data, but there were far too few datum points to permit the use of the predictions with any reasonable level of confidence. It was decided, therefore, to obtain experimental data on acceleration tolerance in the short-duration region on a firm statistical basis. When this was done with mice,<sup>6</sup> it was found that the theoretical model was indeed adequate in the short-duration region.

Rona<sup>7</sup> applies a more complex (continually distributed parameter system) theoretical model to the long-duration acceleration regions, but offers no numerical predictions. Although he finds no experimental correlation of acceleration onset with damage, his theory does predict greater damage for the higher onset rate. In view of the success of the simple linear system<sup>5,6</sup> in predicting and correlating data in

the short-duration region, it was decided to attempt prediction in the long-duration region. Response to the theoretical model is developed in the following section, and then application of the result is made to man's G-tolerance.

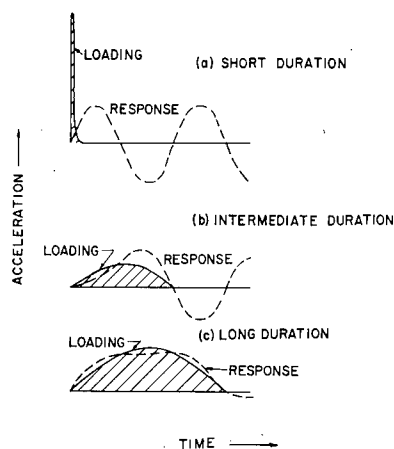


Fig. 1. Loading and response—half-sine pulses.

*Zones of Impact for the Mass-Spring System.*—A form of presentation of shock strength data, originally developed at the U. S. Naval Ordnance Laboratory<sup>4</sup> to describe the performance of inertia mechanisms, appears most suitable for portraying response to single acceleration-time pulses (single versus periodic forcing functions). The data are gathered by subjecting identical specimens to acceleration-time pulses of variable duration and amplitude. At each impact duration the minimum acceleration level which will cause damage is determined. Figure 1 illustrates the manner in which duration affects the peak acceleration necessary to induce a given amplitude level of response. Note that the

From the Missile and Space Vehicle Department, General Electric Company, Philadelphia, Pennsylvania.

shorter the duration of loading, the greater the acceleration required for the same response.

Presentation of the data is accomplished by plotting the parameters  $\Delta V^*$  and average ac-

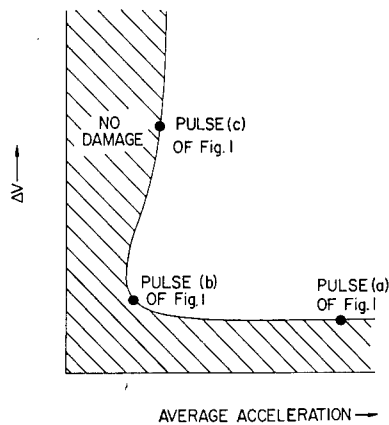


Fig. 2. Sensitivity curve for mass-spring subjected to half-sine pulses.

celeration of each pulse which just succeeded in damaging a specimen. The cross-hatched areas (Fig. 1), constitute the velocity change  $\Delta V$ , while average acceleration is equal to velocity change divided by duration. Figure 2 shows the "sensitivity curve" for a mass-spring system subjected to half-sine pulses. In application of the sensitivity curve, if the  $\Delta V$  and average acceleration of an input pulse lies below or to the left of the curve the specimen experiences no damage, the damaging pulses falling above and to the right of the curve.

Note that the sensitivity curve relates only to the parameters of the input function, no regard apparently being taken of response of the

structure, coupling between mount and structure, and the like. This is done purposely, so that the sensitivity curve may be used in any application where the input acceleration-time history is known. The effects of coupling and structural response are already reflected in the fact that damage was produced, and there is no practical profit in learning the details of the response of each portion of the mount-structure system. As long as one maintains the identical mounting system for identical specimens, the sensitivity curve should prove useful to predict

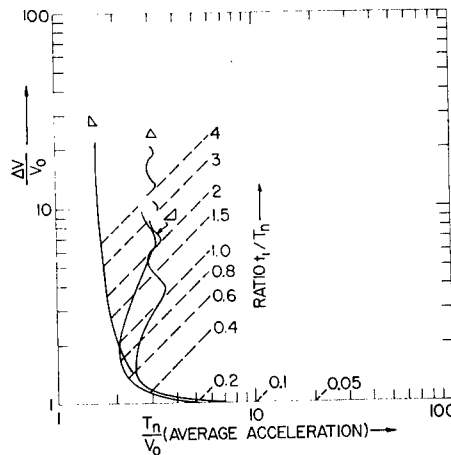


Fig. 3. Sensitivity curve for mass-spring subjected to triangular pulses.

damage or no damage for any application which has known acceleration-time input characteristics.

If the specimens had undergone tests with triangular acceleration-time pulses, the results would be as shown in Figure 3. Obviously, the location of the vertical (or long-duration) asymptote is a function of the shape of the input pulse. This implies the necessity of knowing more about the input pulse than  $\Delta V$  and average acceleration. Note, however, that the horizontal (or short-duration) asymptote is independent of pulse shape, and may be specified by a unique value of velocity change. This constitutes a great simplification of some impact situations, the only specification being that the duration is

\*The following symbols are used in this paper:

$g$ —Acceleration of gravity, 32.2 ft./sec.<sup>2</sup>

$G$ —Applied acceleration,  $g$  units

$G_{av}$ —Time-average acceleration,  $g$  units

$G_0$ —Average steady acceleration just sufficient to induce a given response

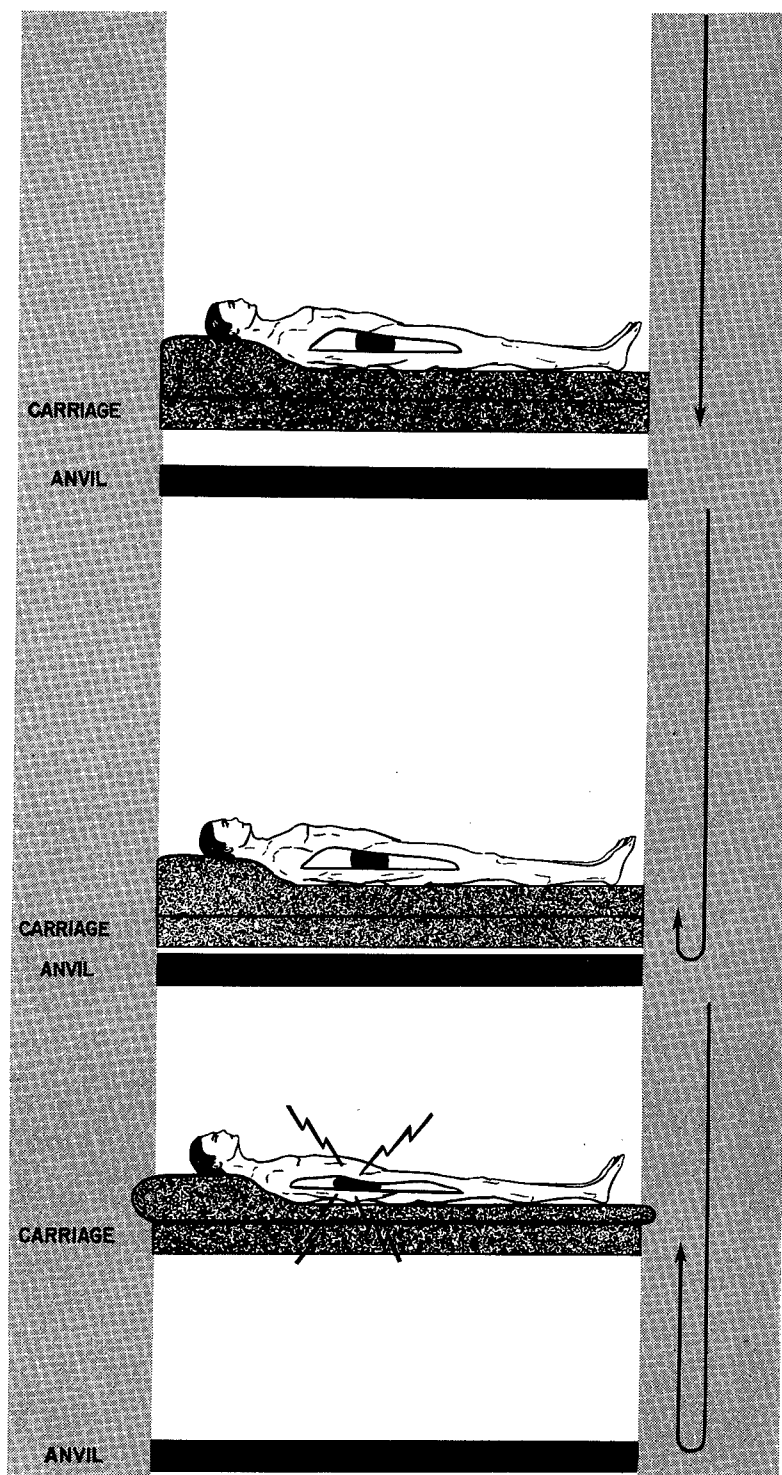
$t_i$ —Duration of impact, or rise time of a pulse

$T_n$ —Natural period of vibration

$V_0$ —Velocity change required to produce a given amplitude of response

$\Delta V$ —Velocity change on impact

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Figs. 4, 5 and 6. (See opposite page)



short enough to be on the short-duration asymptote. Figures 4, 5, and 6 illustrate the physical situation for short-duration loading. These figures show that the low frequency specimen does not respond appreciably during the short time in which  $\Delta V$  is accomplished, the peak response occurring long after the impact. The impact serves to set the mass of the specimen in motion (relative to the carriage), and the inertia of the moving mass produces stress and deformation. For this situation, the only significant impact parameter is  $\Delta V$ .

Figures 2 and 3 apply to mass-spring systems with one degree of freedom. For more complex structures, with several modes of failure, the results might appear as shown in Figure 7. In this case the cross-hatched area would represent the "safe" zone of operation.

Figures 8 and 9 present the theoretical basis for predicting the effects of pulse shape on the long duration asymptote. Note first that both onset rate (or pulse shape) and total pulse

duration are of primary significance for values of  $\Delta V/V_0$  up to about 10. Above this value of  $\Delta V/V_0$  (at which point  $t_1/T_n \cong 3$ , from Figure 3), each curve has essentially reached its verti-

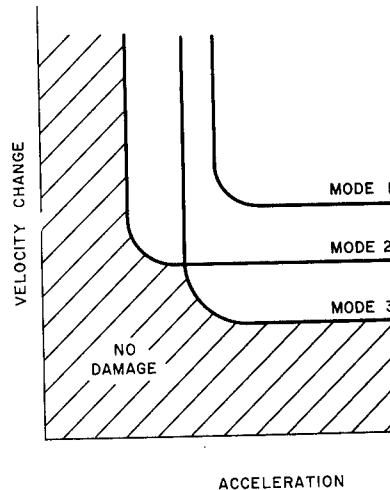


Fig. 7. Sensitivity curve for system with several modes of failure.

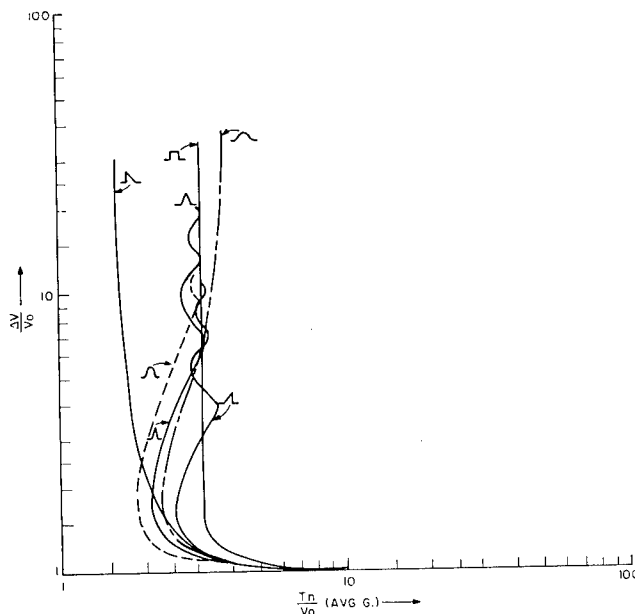


Fig. 8. Theoretical sensitivity curves for mass-spring system (avg. G.).

- Fig. 4. Response of test specimen to short-duration pulse (A) before impact.  
 Fig. 5. Response of test specimen to short-duration pulse (B) immediately after impact.  
 Fig. 6. Response of test specimen to short-duration pulse (C) long after impact.

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cal asymptote, and the effects of onset rate are distinguishable clearly. In this intermediate-duration zone

$$(0.4 < \frac{t_1}{T_n} < 3 \text{ or } 1 < \frac{\Delta V}{V_o} < 10)$$

one may make comparisons of pulse shape and onset effects through the use of Figures 10 and 11.

The fallacy in attempting to correlate G-tolerance data on the basis of onset-rate (or build-up time) alone is illustrated by Figure 12.

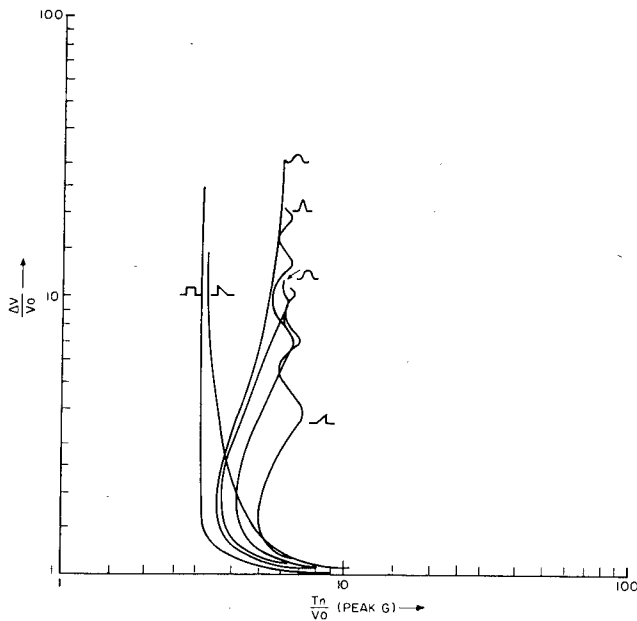


Fig. 9. Theoretical sensitivity curves for mass-spring system (peak G).

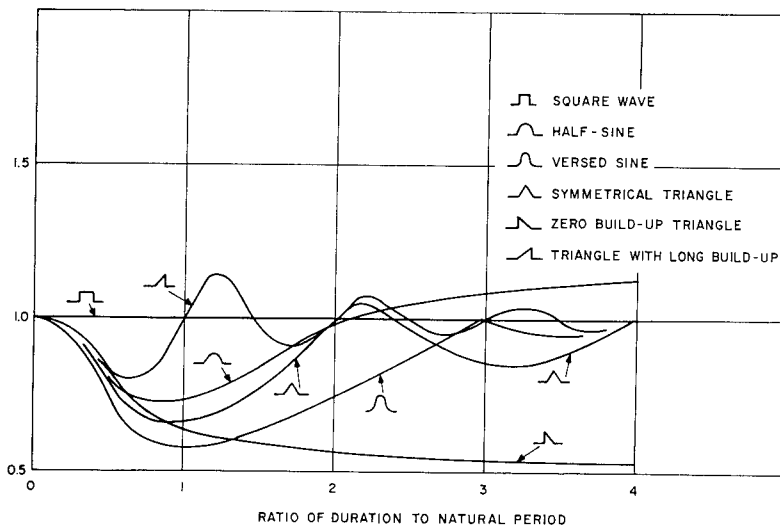


Fig. 10. Comparative velocity change or average acceleration of acceleration-time pulses of equal duration necessary to cause a given deflection of a mass-spring system.

It can be seen that the build-up time (or  $t_p/T$ ) is held constant and the total duration (in Figure 12, the ratio of build-up time to total duration) varied. It may be seen that for ratios of build-up time to natural period less than about 2 or 3, (corresponding to the intermediate-duration zone), the total duration exerts a considerable influence over the G-tolerance. For example, with a fixed build-up time  $t_p/T = 1/4$ , Figure 12 shows relative response values of 0.4, 0.65, and 1.0 for total durations  $t_1/T$  of  $1/4$ ,  $1/2$  and  $\infty$ , respectively. This is equivalent to making an error of a factor of 2.5 (for this example) by considering build-up time to be the determining element in G-tolerance, regardless of total duration.

At very long durations, approaching the centrifuge test situation, one may discern the effects of onset rate directly. Figure 13, taken from data of Herrey,<sup>3</sup> shows the effect of build-up time on a mass-spring system for the linear build-up and the exponential build-up. The am-

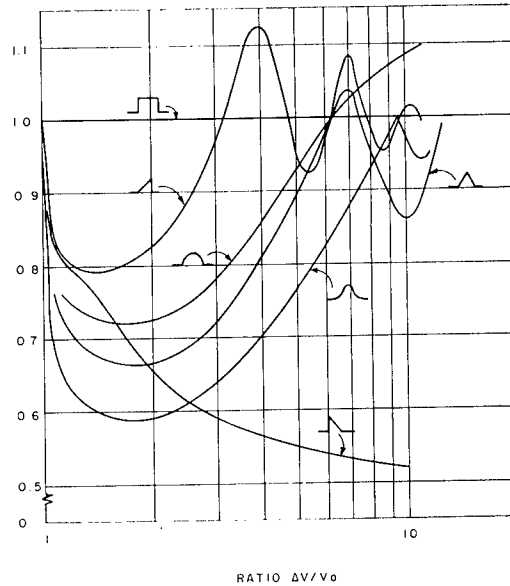


Fig. 11. Comparative average accelerations of acceleration-time pulses of equal velocity change necessary to cause a given deflection of a mass-spring system.

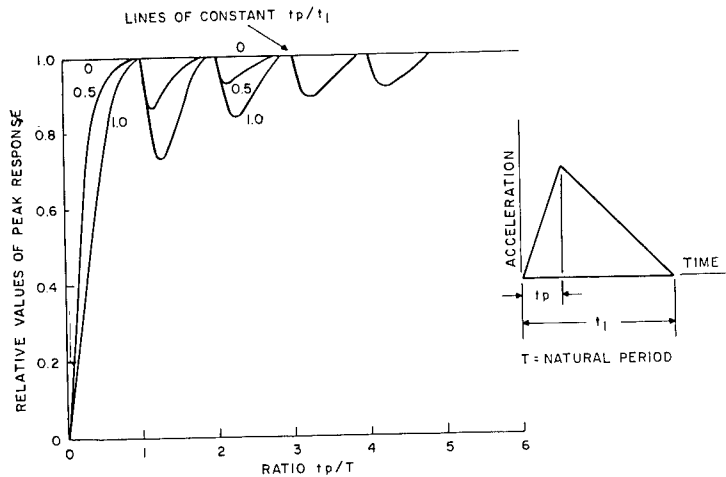


Fig. 12. Effect of total duration of a triangular pulse for fixed values of build-up time.

plification factor drops from 2 at zero build-up time, or infinite rate-of-onset, to the vicinity of 1 for  $t_1/T \geq 2$ . In other words, the infinite onset acceleration pulse requires only half of the slowly-applied acceleration for its "plateau"

acceleration level to cause the same degree of damage.

The above theoretical findings may be summarized by assigning "zones of impact" to the impact sensitivity curve (Figs. 8, 9, or 14).

## 1. Short-duration impact zone,

$$0 < \frac{t_1}{T_n} < 0.4, \Delta V = V_0.$$

In this zone, onset rate, pulse shape, or peak acceleration have negligible influences; only velocity change is important.

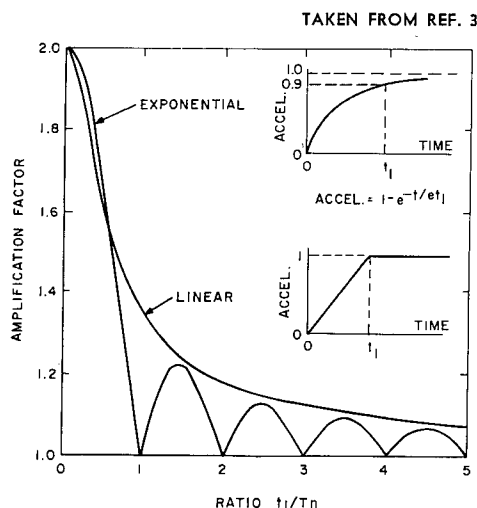


Fig. 13. Effect of build-up time on mass-spring system.

2. Intermediate-duration impact zone,  $0.4 < t_1/T_n < 3$ ,  $1 < \Delta V/V_0 < 10$ . Both onset rate and total pulse duration are important, with a spread of a factor of two in acceleration required to cause a given degree of damage at a fixed value of velocity change (Fig. 11).

3. Long-duration acceleration zone,  $t_1/T_n > 3$ ,  $\Delta V/V_0 > 10$ . Onset rate is the primary influence here, with a spread of a factor of two between the slowly rising acceleration pulse and the infinite-onset-rate pulse.

*Application of the Theory to Man.*—Figure 14 presents the experimental data on human impact strength (supine position) in the form of a sensitivity curve. The value of this form of presentation is evidenced by the two asymptotes, which enable one to state simply that the criteria of damage are 20 g and 80 fps velocity change, both of which must be exceeded con-

currently for damage to occur to a well-supported human in the supine position. Of course, this statement is a gross oversimplification, and it should be refined whenever there is sufficient information available to warrant refinement.

Major sources of data are indicated on Figure 14, by the cross-hatched zones. Since these experimental zones of data procurement correspond fairly well to the "zones of impact" discussed above on a theoretical basis, it is pertinent to discuss theoretical predictions versus practical results for each zone. Zone No. 1 of Figure 14 is the short-duration impact zone, the data for which are collected sporadically as a result of survival of air crashes and suicide attempts.<sup>1,2,5</sup> As a result of this unsystematic

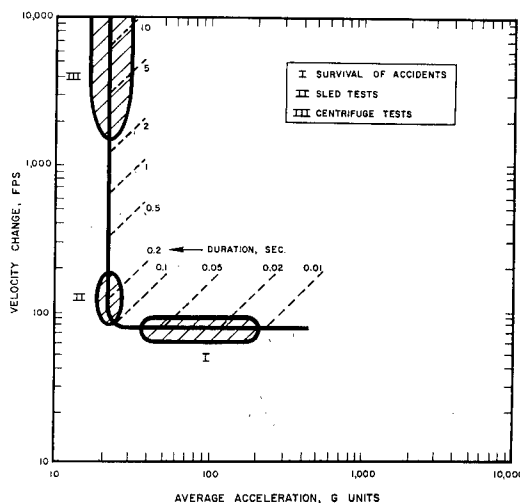


Fig. 14. Human impact sensitivity curve.

collection of data, the short-duration asymptote for man is based on only five or six datum points. It was because of the uncertainty that the experimental points truly lie along the horizontal asymptote predicted by theory, that an experimental mouse impact program was instituted in this laboratory. Using specimens in statistical numbers, it was established<sup>6</sup> that there is a short-duration asymptote, at least for mice. This thorough information on mice, as well as the somewhat scanty data for humans (Fig. 14) and hogs<sup>9</sup> constitutes the best data available at

present for proving the existence of short-duration asymptotes for animals.

A most significant result was obtained with the mice, in the form of scatter of the data. Using a genetically pure strain of mice of one sex, all the same age, with controlled laboratory testing conditions, it was found that the short-duration asymptote was really a wide band as follows:

- (a) 1 per cent mortality level  $\cong$  28 fps
- (b) 50 per cent mortality level  $\cong$  38 fps
- (c) 99 per cent mortality level  $\cong$  49 fps

In view of this large spread in the data for "reproducible" specimens, one should anticipate an even greater scatter for human response data.\*\* A recommended safe value for the short-duration asymptote would, therefore, be about 50 fps, rather than the 80 fps limit shown in Figure 14, as follows:

$$V_o = 50 \text{ fps} \quad \text{Eq. (1)}$$

Zone No. 2 of Figure 14 is the intermediate-duration impact zone, the data for which were obtained primarily through sled tests at Holloman Air Force Base.<sup>8</sup> Pulse shape and onset-rate effects are not discernible, since these parameters were not investigated systematically with the large number of tests required to isolate such effects within the usual scatter of data. Using  $V_o$  from Eq. (1), the intermediate zone may be seen to extend from 50 fps to 500 fps, with the following average value of  $G_o$ :

$$G_o = 20 \text{ g} \quad \text{Eq. (2)}$$

Zone No. 3 of Figure 14 is the long-duration acceleration zone, with velocity change exceeding about 500 fps. The great bulk of experimental data on human G-tolerance has been obtained in this zone, through centrifuge testing. Although Figure 14 shows the long-duration asymptote fairly constant at about 20 g, the

plot ends at 10,000 fps. Centrifuge tests of longer duration, or greater velocity change, show that G-tolerance decreases with increasing duration. To explain this phenomenon in terms of the mass-spring model one may assume that several different modes of failure are presented by the one curve; as shown, for example, in Figure 7. In this zone, as in Zone No. 2, onset effects are not distinguishable within the experimental results.<sup>7</sup> It is desirable, therefore, to estimate theoretically the effects one would anticipate due to changes in rate-of-onset, and this analysis is done in the following paragraphs.

*Prediction of Onset-of-Acceleration Effects.*— Since we have deduced that onset rate and total duration are both of primary importance in the intermediate-duration impact zone, it does not appear feasible to make simplifications and generalizations beyond those possible through use of Figures 8 through 11. If one does have knowledge of a pulse shape to be expected in practice, one may apply the predictions of Figures 8 through 11. If not, the theoretical factor of safety to account for any† simple pulse shape is a factor of 2.

Theoretical predictions are possible, however, in the long-duration acceleration zone ( $\Delta V > 500$  fps). A simple relationship (the value of the vertical asymptote for the slowly-rising pulses in Figure 8) permits easy determination of the effect of the natural period,  $T_n$ , for man in his impact mode of damage as follows:

$$\frac{G_o T_n}{V_o} = \Pi \quad \text{Eq. (3)}$$

Substituting values of  $V_o$  and  $G_o$  from Eq. (1) and Eq. (2), respectively, leads to  $T_n = 0.244$  seconds. G-tolerance versus onset-rate may now be determined by selecting ratios  $t_1/T_n$  and finding amplification factors from

\*\*Note that Captain Beeding's famous sled test involved a velocity change of only about 48 fps, well below the 80 fps asymptote of Figure 13, and he suffered severe (but reversible) reactions.

†This statement is true only for single positive acceleration time pulses. Cyclic pulses, which involve excitation of natural resonances of the test specimen, can produce amplification factors well above 2.<sup>10</sup>

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Figure 13. For  $G_0 = 20$  g, G-tolerance is found as follows:

$$G = G_0 / \text{amplification factor} \quad \text{Eq. (4)}$$

Onset-rate is equal to  $G/t_1$ , where  $t_1 = 0.244$  ( $t_1/T_n$ ).

damping, probably well below 20 per cent of critical damping. One would therefore expect the effect of the damping terms to be minor when applied to the mass-spring model for man.

In practice it may prove quite difficult to isolate rate-of-onset effects for man, even under experimental conditions controlled to the

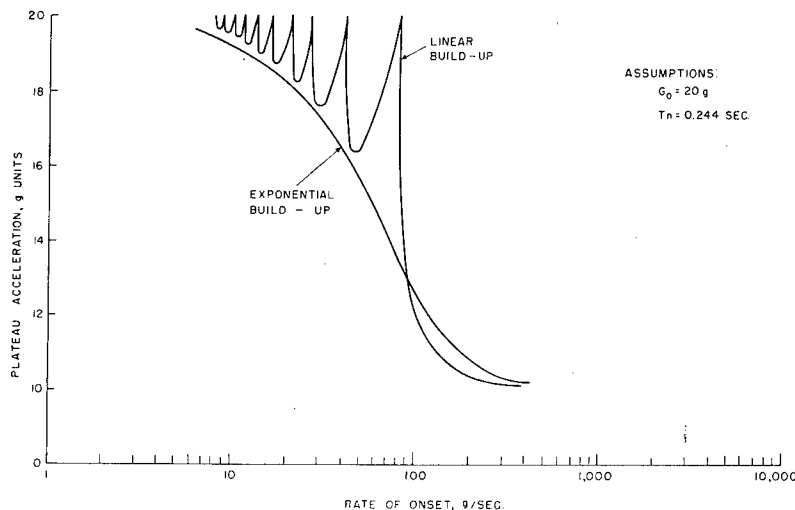


Fig. 15. Effect of onset rate on man's G-tolerance.

Figure 15 presents the theoretical prediction of  $G$  versus onset-rate for the long-duration acceleration zone. Very roughly, it may be seen that  $G$ -tolerance is essentially 20 g for onset rates less than 10 g/sec., dropping to the vicinity of 10 g as onset rate increases to about 100 g/sec. and remaining at 10 g for onset rates above 100 g/sec. In view of the success of the theoretical model in predicting experimental behavior on the short-duration asymptote, it is anticipated hopefully that the predictions on Figure 15 will be useful in guiding the course of onset-rate experimentation.

The inclusion of a damping term in the theoretical model has the effect of decreasing the influence of onset rate, as may be seen in Figure 16. For example, a critically-damped system would have a constant tolerance of 20 g, regardless of onset rate. It must be noted, however, that most mechanical systems, including living tissue, have rather low values of

best capabilities of our present impact technology. The following factors are involved:

1. The maximum effect to be isolated seems to be a factor of 2 (Fig. 15).
2. The linear build-up curve of Figure 15 is quite sensitive to small changes in onset rate, which would lead experimentally to what would appear to be widely scattered results.
3. As mentioned before, the "reproducible" mice varied by a factor of 2 in  $G$ -tolerance on the short-duration asymptote. One could therefore expect greater variability in results for man on the long-duration asymptote.

For the above reasons, it is recommended that early rate-of-onset experimentation be performed under precisely controlled laboratory conditions, using the simplest and most predictable organisms as test specimens. Successful isolation of rate-of-onset effects under these circumstances would then warrant the cruder experimental programs for man.

# MAN'S G-TOLERANCE—KORNHAUSER

## SUMMARY

The effects of build-up time and of total duration of acceleration-time pulses on man's G-tolerance are predicted within the framework of a simple theoretical mass-spring model. It is demonstrated both theoretically and experimentally that a short duration impact regime exists in which neither pulse shape nor pulse

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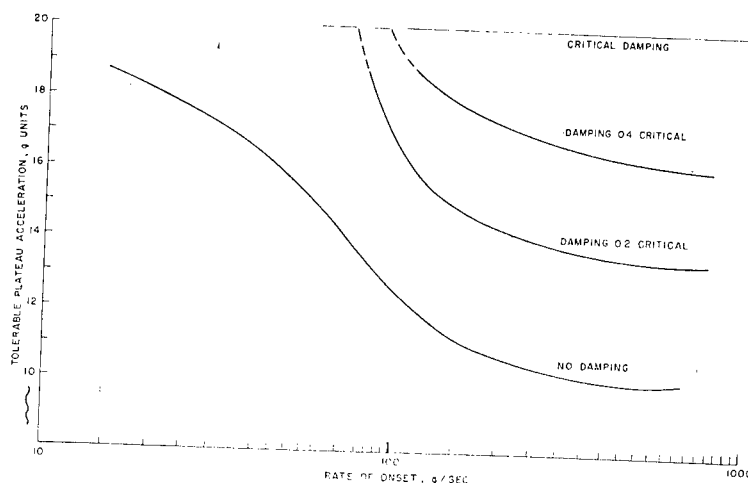


Fig. 16. Effect of damping on man's G tolerance to loadings with exponential build-up.

duration is significant, velocity change being the governing criterion of damage. At intermediate durations (0.1 to 1 second), theory indicates that both pulse duration and onset rate are of paramount importance; while response to the long duration pulses (duration greater than 1 second and  $\Delta V > 500$  fps) of equal acceleration is shown theoretically to depend on rate-of-onset. For these long duration acceleration pulses, it is estimated that man's G-tolerance remains at the centrifuge value of about 20 g for onset rates less than 10 g/sec., dropping to about 10 g for onset rates above 100 g/sec. The difficulties in detecting these onset effects experimentally are discussed.

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# Orbital Characteristics of Earth and Moon Satellites

## As a Basis for Space Medical Studies

HUBERTUS STRUGHOLD, M.D., Ph.D. and OSKAR L. RITTER, Ph.D.

**I**N A RECENT publication,<sup>1</sup> the gravitational situation in solar space has been discussed with regard to the spheres of significant gravitational influence, or *gravispheres*, of the planets from Mercury to Pluto and of several moons. It was pointed out that a distinction can be made between the inner part of the gravisphere and the outer gravisphere. The inner gravisphere is the region within which the gravitational influence of a celestial body is dominant, in the sense that it can hold another body captive in orbit as a satellite. This region, therefore, can also be called the *potential satellite sphere* of the body. As an example, the earth's potential satellite sphere reaches as far as one and one-half million kilometers (one million miles), or four times the distance to the moon. In the outer gravisphere, extending several million miles beyond this region, the earth still exerts a marked if decreasing influence upon the orbit of another celestial body or a space vehicle.

The recent successes in the penetration of space with unmanned vehicles puts this spatial gravitational aspect more and more into the focus of astronautical and public interest. It therefore appears useful to discuss in more detail the gravitational situation in that region which is of immediate astronautical interest: the earth-moon area. We shall here concentrate our attention especially upon the orbital velocities and periods of revolution of artificial satellites at various levels within the gravispheres of the earth and the moon. This is of space medical interest insofar as it gives information about the periods of time during which a satellite moves through the shadow of the primary celestial body or is exposed to solar irradiation. It

is also of particular interest with regard to the Van Allen Radiation Belt of earth.<sup>3</sup>

As already mentioned, the potential satellite sphere of the earth has a radius of  $1.5 \times 10^6$  kilometers (930,000 miles). So far, in a careful search by C. Tombaugh and co-workers,<sup>2</sup> no other natural satellites of earth (except the moon) have been found with a brightness larger than 15th magnitude, which corresponds to a size of about 1 ft. diameter at a height of 1000 miles, or 1000 ft. at the boundary of the satellite sphere. The moon, at a mean distance of 384,000 km. (239,000 miles), moves with a mean orbital velocity of 1.0 km./sec. (0.63 mi./sec.) in 27.3 days around earth. The orbital velocity near the earth's surface, if earth had no atmosphere, is 7.9 km./sec. (4.9 miles/sec.). Of course, we can not reckon with satellites of noteworthy lifetime below 200 km. (120 miles) due to atmospheric drag.

Table I shows the orbital velocities and periods of revolution at this mechanical border of the atmosphere and above at selected intervals. The first part of the table covers the space below the Van Allen Radiation Belt which may permit manned satellite flights.

The second part of Table I gives orbital data in various intervals up to 70,000 km. (43,000 miles), including the often discussed 24-hour orbit at 36,000 km. (22,300 miles). This range covers the greater part of the Van Allen Radiation Belt and permits derivation of the fraction of time during which a vehicle in a polar or otherwise inclined orbit would be exposed to their radiations.

The third part of Table I shows the orbital velocities and periods of revolution up to the border of the satellite sphere (neglecting perturbations by the moon and sun). This range

From the Advanced Studies Group, USAF Aerospace Medical Center, Brooks Air Force Base, Texas.



# ORBITAL CHARACTERISTICS—STRUGHOLD AND RITTER

TABLE I. EARTH SATELLITES

Altitude above Surface km	Distance from Center km	Distance in Units of Earth's Radius —	Distance in Per Cent of Radius of Earth's Gravisphere %	Speed in Orbit km./sec.	Period of Revolution (sidereal) days hr. min.	Altitude above Surface miles
( 0	6,371	1	.425	7.909	1 24	0)
( 100	6,471	1.016	.431	7.848	1 26	62)
200	6,571	1.031	.438	7.788	1 28	124
300	6,671	1.047	.445	7.729	1 30	186
400	6,771	1.063	.451	7.672	1 32	249
500	6,871	1.078	.458	7.616	1 34	311
600	6,971	1.094	.465	7.561	1 37	373
700	7,071	1.110	.471	7.507	1 39	435
800	7,171	1.126	.478	7.455	1 41	497
900	7,271	1.141	.485	7.403	1 43	559
1,000	7,371	1.157	.491	7.353	1 45	621
1,500	7,871	1.235	.525	7.116	1 56	932
2,000	8,371	1.314	.558	6.900	2 07	1,243
3,000	9,371	1.471	.625	6.521	2 30	1,864
5,000	11,371	1.785	.758	5.920	3 21	3,107
10,000	16,371	2.570	1.09	4.934	5 47	6,214
20,000	26,371	4.139	1.76	3.888	11 50	12,427
35,868	42,239	6.630	2.82	3.072	1 00 00	22,287
50,000	56,371	8.848	3.76	2.659	1 13 00	31,069
70,000	76,371	11.987	5.09	2.385	2 07 54	43,496
	100,000	16.70	6.67	1.996	3 15 26	
	150,000	24.54	10.0	1.630	6 16 37	
	200,000	32.39	13.3	1.412	10 07	
	300,000	48.09	20.0	1.153	18 22	
	384,405	60.33	25.6	1.018	27.3	
	500,000	79.48	33.3	.898	40.5	
	700,00	110.9	46.7	.759	67.1	
	1,000,0'	158.0	66.7	.635	114.5	
	(1,500,000	236	100	.519	210 )	

included the moon's orbit. At one million km. a satellite would require 114 days to circle the earth. As already mentioned, the potential satellite sphere of earth reaches up to  $1.5 \times 10^6$  km. This is the dynamical gravitational divide between the earth's gravisphere and that of the sun.

With reference to the Van Allen Belt, we may call the orbits below the Belt "low orbits"; those within the range of the Radiation Belt "medium orbits"; and those above, "high

orbits." This subdivision is of space medical significance with regard to shielding.

The moon moves within the earth's gravisphere with a sphere of predominant gravitational influence of its own. It extends to 58,000 km. (36,000 miles) on the cislunar side and to 64,000 km. (40,000 miles), in the trans-lunar direction. The moon's gravity is about 17 per cent of that of earth. Consequently, the circular velocity near the moon's surface is 1.7 km./sec. (1 mile/sec.).

TABLE II. MOON SATELLITES

Altitude above Surface km	Distance from Center km	Distance in Units of Moon's Radius —	Distance in Per Cent of Radius of Moon's Gravisphere %	Speed in Orbit km./sec.	Period of Revolution (sidereal) days hr. min.	Altitude above Surface miles
( 0	1,738	1	2.85	1.679	1 48	0 )
( 10	1,748	1.0058	2.87	1.675	1 49	6.2)
30	1,768	1.017	2.90	1.665	1 51	31.1
100	1,838	1.058	3.01	1.633	1 58	62.1
200	1,938	1.115	3.18	1.590	2 08	124.3
500	2,238	1.288	3.7	1.480	2 38	311
1,000	2,738	1.575	4.5	1.338	3 34	621
2,000	3,738	2.151	6.1	1.145	5 42	1,243
5,000	6,738	3.877	11.0	.853	13 47	3,107
10,000	11,738	6.754	19.2	.646	1 7 42	6,214
20,000	21,738	12.5	35.6	.475	3 7 54	12,427
(59,000	61,000	35.1	100	.283	15 16	37,000 )

## ORBITAL CHARACTERISTICS—STRUGHOLD AND RITTER

Table II presents the orbital velocities and periods of revolution of moon satellites in selected intervals up to 20,000 km. The data beyond must be considered as theoretical because of the increasing influence of disturbances from earth. If the moon were an independent celestial body, a theoretical satellite at a distance of 87,000 km. would require the same period of revolution around the moon as the moon requires around the earth.

All the data in the tables refer to circular orbits around the earth or around the moon. In reality, most of the artificial satellites move and will move in more or less elliptic orbits. Nevertheless, the data on the periods of revolution are applicable as long as the semi-major

axis of an ellipse equals the radius of a circular orbit. These data provide a more distinct picture of the gravitational situation in the earth-moon areas, useful for navigational and space medical considerations.

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## Personal Problems Affecting Flight

The pilot of an FJ-4B lost directional control and swerved off the runway on attempted takeoff. At the time of the accident, the pilot was beset with extremely severe personal problems. His troubles were unknown to any of his fellow officers or his flight surgeon because the squadron had just reformed following deployment.

In his report the flight surgeon states that it is felt that the pilot was not psychologically suited to be flying at the time of the accident because of this stress. This could well have been the contributing factor in causing him to become fixated on getting airborne, the flight surgeon states. This accident, he notes, points out the necessity of the flight surgeon knowing his pilots intimately. . . . Later, investigators found the automatic parachute opening cable still attached to the parachute. If it had been hooked up properly when the pilot strapped in, it would have remained attached to the lap belt after seat separation.

The pilot recalled that he had had difficulty in attaching the ring of the automatic parachute opener to the lap belt release mechanism. Actually, he had strapped in without hooking the automatic parachute opener. If he had been unconscious or dazed after ejecting he would have been unable to actuate his parachute manually. If he had ejected at a low altitude he would not have had time to manually actuate the parachute. In either case he would have been killed.—From *Approach*, July, 1960.

## High G Protection

R. F. GRAY and LT. CDR. M. G. WEBB, MC, USN

**S**TANDARD G suits increase tolerance to positive acceleration by squeezing against the abdomen, thighs, and calves of the legs. This helps maintain circulation to the head despite the effects of acceleration tending to stop such circulation. The standard types of G suits issued to flyers will increase G tolerance by about 1.5 G.<sup>7</sup> If, for example, a pilot has a normal tolerance level of 5 G, the standard G suit will permit him to tolerate 6.5 G. Experiments with bladder systems have indicated that increasing the body area pressurized and increasing the pressure would increase G tolerance by about 3 G.<sup>10</sup> There was, however, an accompanying decrease in comfort.

Investigators concerned with augmenting G tolerance by use of these procedures were hesitant to try continually increasing pressures and pressurized area because of the indicated hazards. The G suit which carries the concept of increased area to the extremes is the Full Pressure Half Suit (FPHS) which applies pressure to the entire body below the level of the chest. When these suits are inflated at the rate of 1.0 psi/G they give an increase in tolerance of about 3 G.<sup>1</sup> They also give an increase in tolerance of about 3 G when inflated at 1.2 psi/G.<sup>8</sup> The limit in both cases is established by subject discomfort. It is to be noted that when 1.2 psi/G was utilized in the FPHS, the subjects developed cardiac arrhythmias as indicated by the ECG.

Presented at the Aerospace Medical Association meeting, Los Angeles, California, April 27-29, 1959.

From the U. S. Naval Air Development Center, Aviation Medical Acceleration Laboratory, Johnsville, Pennsylvania.

The opinions and conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or the endorsement of the Navy Department.

Animals have died when exposed to many consecutive positive acceleration experiences.<sup>9</sup> Those not protected by pressure on the lower body showed considerable respiratory distress before dying and it has been suggested that this was due to central nervous system damage. Those which died when protected by pressure on the lower body did not show this respiratory distress. They died suddenly although they appeared behaviorally to be in good condition. Autopsies indicated an accumulation of blood in the heart and lower lungs and it was concluded that death was due to heart failure following repeated over-distention of the heart with blood.

Several investigators have suggested filling the chest with fluid of about the density of blood to solve the problem of protecting the heart and lungs against positive acceleration by countering the hydrostatic pressure of the blood in these organs with the hydrostatic pressure of the fluid. Additionally, it was suggested that the outside of the body should be immersed in water for similar reasons. Submersion in water for G protection without a fluid-filled respiratory system has been studied since the early 1940's and led to the water-filled Frank's Flying Suit.<sup>3</sup> These studies indicated about the same increase in G tolerance which could be gained with air-pressurized devices, therefore the decision was made to utilize the air-inflated G protective suits in operational use rather than the water-filled suits.

More recently, the principles of water immersion have been reinvestigated at Johnsville utilizing, in addition to past procedures, increased air pressure in the chest in the hope of gaining increased acceleration tolerance and thus avoiding for a while the problems associated with the fluid-filled respiratory system. The increased air pressure in the respiratory system has been

employed at Johnsville to prevent the accumulation of blood in the thoracic cavity and this respiratory air pressure has also been shown to aid the heart in pumping blood to distal re-

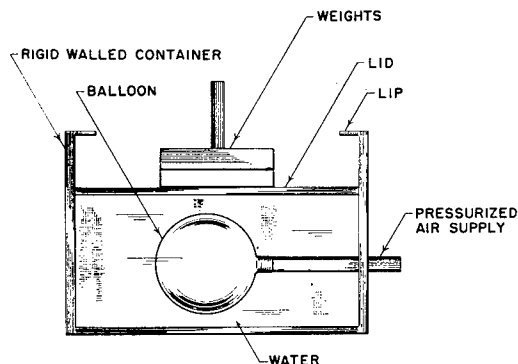


Fig. 1. Mechanical model illustrating pressure action.

gions of the body against the increased hydrostatic head of blood developed by acceleration.

#### MODEL STUDIES

The principles of water protection as currently used at Johnsville were developed by the use of mechanical models.

I. Figure 1 illustrates this model. The tank is rigid; the piston is limited in upward travel; and the balloon can be inflated and sealed at various pressures. If a weight is put on the piston, the piston will move downward and the volume of the balloon will be reduced. If, then, more pressure is put in the balloon, the piston will be raised and the balloon increased in volume. If enough air pressure were put in the balloon at the start to force the piston very strongly against the limits of upward travel, and air was sealed in the balloon, then a considerable amount of weight could be put on the piston without reducing the volume of the balloon. Since the volume of the balloon did not change, then the addition of weight on top of the piston would not act to change the air pressure within the balloon. Eventually, enough weight could be placed on top of the piston to start reducing the volume of the balloon and increasing the pressure within the balloon.

**Conclusion.**—This model illustrates that until the pressures acting to compress the balloon exceed the air pressure tending to expand the balloon, the compressive force could not act to reduce the volume of the balloon.

**Discussion.**—If the top of the model were immovable and rigid, like the walls, and the model were exposed to acceleration, the weight tending to compress the balloon would be that of the water. If the air pressure in the balloon were one atmosphere then the equivalent hydro-

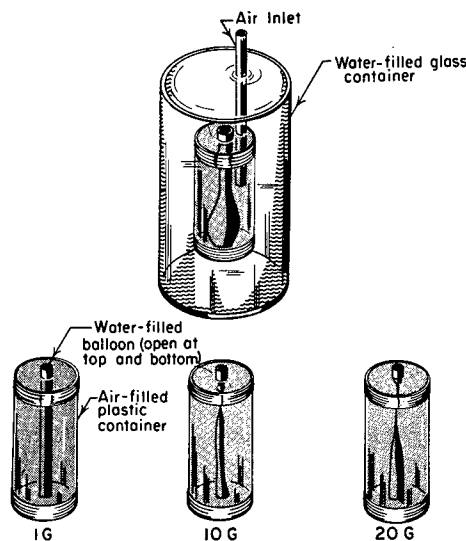


Fig. 2. Physical model of distortions produced by acceleration.

static head necessary to compress the balloon would be 33 feet of water. During rotation, a one-foot high column of water would develop a pressure of one atmosphere, at the bottom, at an acceleration level of 33 G.<sup>4</sup> The pressurization requirement for maintaining constant thoracic volume thus is indicated to be one atmosphere of pressure per foot of respiratory system depth per 33 G.

II. With increased acceleration, however, there is an increased gradient of hydrostatic pressure acting on the air-filled spaces. It was found by use of a second model (Fig. 2) that this increased gradient of hydrostatic pressure distorted the constant volume air-filled space and, of

course, distorted the fluid-filled balloon within the air-filled space.

**Conclusion.**—This model helped to recognize that possibly, during positive acceleration, the blood vessels at the top of the chest might collapse and stop circulation to the head, that blood would tend to accumulate in the dependent regions of the chest and that there would be a tendency for air to move upward towards the center of rotation.

### III. In order to judge whether or not the

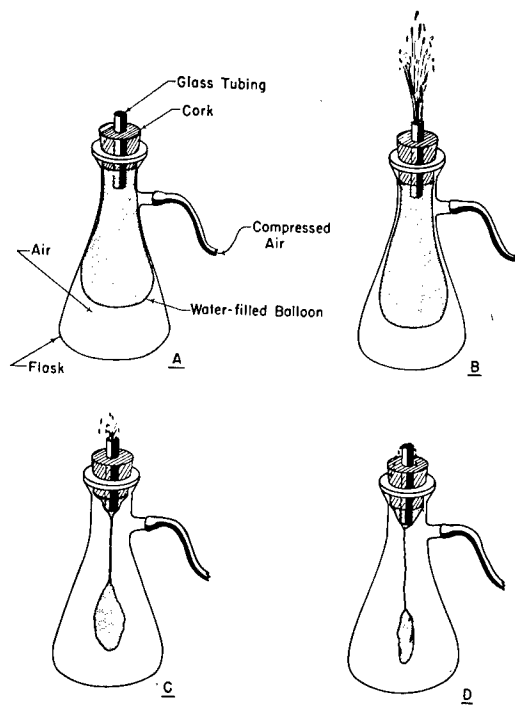


Fig. 3. Physical model showing effect of increased air pressure on water-filled balloon.

circulation to the head could possibly be maintained through large collapsed intrathoracic vessels, the mechanical model illustrated in Figure 3 was assembled. Figure 3A shows the arrangement of the water-filled balloon in a large flask with air at ambient pressure. Figure 3B shows that, as air pressure was increased on the surface of the balloon, water shot out of the glass tube in the cork. As the water was forced out

of the balloon by the increased air pressure, the top portion of the balloon collapsed (Fig. 3C); however, water continued to move out of the balloon but at a decreased rate, due to the

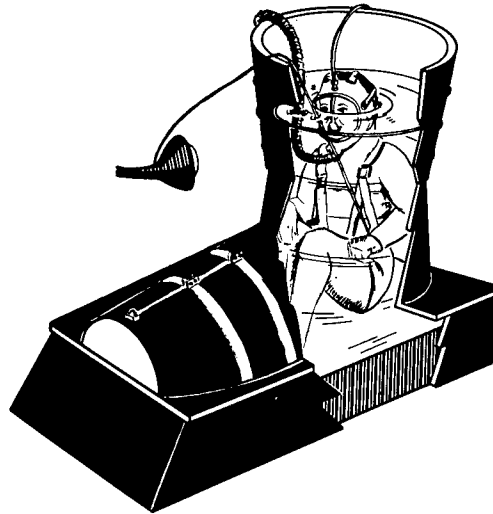


Fig. 4. Subject submerged in Mayo tank for positive G study.

decreased size of the lumen. Finally (Fig. 3D), all of the water was forced from the balloon, but due to the greatly increased resistance to water movement caused by the continually decreasing patency of the collapsed portion, the water left the balloon in only a slow trickle.

**Discussion.**—Thus, if the systemic circulatory system within the thorax were analogous to the mechanical model, increasing or increased intrapulmonic pressure might help the heart move blood out of the chest at high G, especially since with increasing acceleration, the water pressure at head level would become progressively less than that in the chest. The heart might act to maintain unidirectional flow through the circulatory system by superimposing on the differences in pressure developed by acceleration, the difference in pressure between the arterial and venous circulations.

**Conclusion.**—The air pressure was able to move water out of a balloon even though a

region of the balloon was collapsed by this same air pressure.

#### HUMAN STUDY I

*Method.*—Concepts of G protection through means of water immersion in conjunction with pressurization of lungs were first tested on humans at Johnsville in a very simple manner.<sup>9</sup> The subject sat in a shoe-shaped tank which had been used previously in 1942-43 at the Mayo Clinic (Fig. 4). Just prior to the period of acceleration, the subject held his breath and submerged to eye level in the seated position. With increased acceleration the water compressed his chest and increased the internal air pressure. This method of chest pressurization was chosen because the increasing pressure was associated with lessening chest volume and thus the hazard of emphysema and air embolism associated with chest expansion was reduced. Such effects had been observed in SCUBA diving and in some unreported studies with animals submerged on the Johnsville animal centrifuge while breathing from a balloon in the water beside them.

As each run started, the subject fixed his gaze on a light in front of him in the center of his visual field and turned off lights in the periphery of his visual field whenever they were turned on. These lights were turned on at random intervals. Failure to respond to the peripheral lights within 1.5 seconds was assumed to mean loss of peripheral vision and was utilized as one indication of having reached a limit of acceleration tolerance.

*Results.*—Two subjects sustained levels of 10 and 10.5 G respectively without reaching tolerance limits, then could no longer act as subjects for reasons not connected with the experiment. A third subject achieved a level of 16 positive G without dimming of the visual field. Air forced upward from his chest led to a stretching of cheeks and other facial tissues and taping the mouth helped him retain higher pressures. However, under these conditions severe irritation of the pharynx by air passing upward and out through the nose was the first

sign of trouble and precluded attempts to attain higher acceleration levels. The subject lost peripheral vision at 3.25 G when there was no water in the tank so that his gain in positive G tolerance with the protective system was 13 G, or more than four times the increase in positive G tolerance which could be gained by the most effective experimental G-suits and eight times the protection to be gained with standard G-suits.

*Conclusions and Discussion.*—Water submersion with respiratory system pressurization can give considerable increase in tolerance to positive acceleration, but a means of protection against upward translocations of respiratory gases is required for increases in acceleration tolerance beyond 16 G. It is to be noted that the increased protection in this system was gained despite respiratory gas pressure increases in the mouth and neck as well as in the chest. This indicates that it may be possible to protect against air translocations from the chest upward with a mask covering the neck and lower face while still retaining the protective effects of respiratory system pressurization. Such a mask has been designed and it couples to a rigid aluminum cuirass designed to protect against upper chest expansion.

#### HUMAN STUDY II

*Methods.*—A G capsule was designed to utilize various mechanical principles herein discussed (Fig. 5).<sup>4</sup> It is a rigid, semiform-fitting, sheet aluminum structure built by the David Clark Company and the CPC Engineering Company. The subject is completely submerged in water and breathes through a tube attached to a mask. Between periods of rotation, his breathing moves a water column up and down in the standpipe at the back. Water level in the stand pipe can be adjusted for respiratory comfort. Just prior to centrifugation all valves are closed. These valves all operate under water and closing them separates the outside of the subject's body from the ambient air. Thus, the air present in his respiratory system has only to oppose hydrostatic pressure rather than hy-

drostatic pressure plus atmospheric pressure. In this way, one atmosphere of respiratory pressurization is established without pumping air into the subject.

Air has been pumped into and out of the subjects to provide respiration but a high enough level of pressurization has not yet been achieved for satisfactory respiration above 25 G. Respiratory pressurization has been limited by ear and frontal sinus pain occurring because of the rapid change in pressure and most high G runs were conducted with the subject holding his breath.

So far, since no adequate mask has been available for studies in the positive G position, subjects have been studied in the G capsule only in the prone position, facing away from the center of rotation. The acceleration pattern as a function of time was a 25-second haversine.

**Results.**—Subjects again turned off lights in the periphery of the visual field as they were turned on at random intervals. Since under the conditions of the experiment, loss of peripheral vision seemed unlikely, these responses indicated something about the performance ability of the subjects. One subject has attained a level of 26 G. No attempt was made to take him to a higher G level because his breath-holding ability deteriorated with continued exposure. Following a run at 23 G he reported seeing blood on his handkerchief after blowing his nose. A second subject went to a level of 28 G. His respiration pressure was varied by use of a G valve and reached a level of 7 psi above atmospheric. At 28 G this subject suffered frontal sinus pain. Following this run there were flecks of blood in the material he blew from his nose. His frontal sinus pain lasted three weeks and he was not utilized any further as a subject in this study. A third subject went to a level of a little over 31 G. He experienced a slight frontal sinus pain at this level but not at lower levels. The following morning when he first blew his nose, bloody mucous was observed.

All three subjects experienced abdominal pain during this centrifugation. This pain could usually be eliminated by tightening the ab-

dominal muscles. For one subject the pain was not a function of G-level. Another subject had to strain harder at higher G levels in order to eliminate the pain.

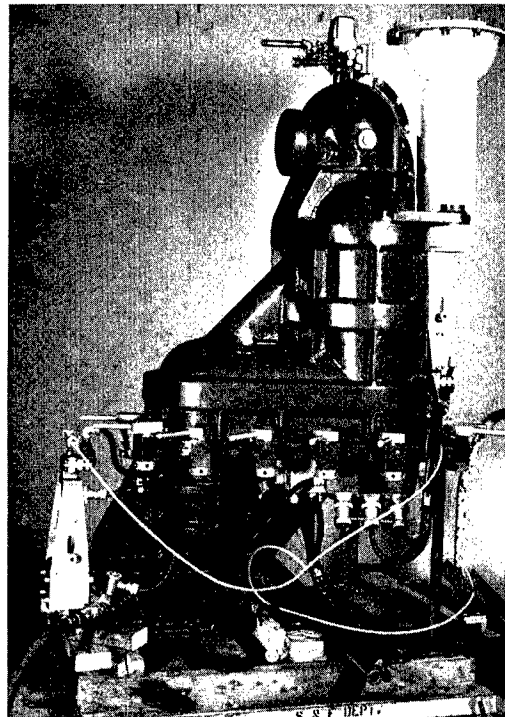


Fig. 5. G capsule designed to utilize various mechanical principles herein discussed.

There was no indication of impairment of vision during the period of centrifugation and glasses correcting for submersion of the eyes provided clear vision. No eye pain was experienced even though all subjects exceeded G levels at which severe eye pain had been reported by subjects in a similar orientation during previous centrifuge and rocket sled studies. No subject reported leg pain such as often limits tolerance to acceleration in this position. Although a rigid vest was available to oppose overexpansion of the chest at the rear of the capsule, it was not used because a sensation of chest distortion was not experienced.

One advantage of water immersion is the ability to move the arms and legs freely, even while under very high accelerations. One sub-

# HIGH G PROTECTION—GRAY AND WEBB

ject reported a slight flotation of his chest toward the center of rotation at 16 G and a movement of his hands away from the center of rotation. Another subject at 10 G felt a slight movement of his hips away from the center of rotation but did not observe this at higher G levels, possibly because of paying attention to other things. Post-run clinical examinations indicated no congestion within the chest and ECG abnormalities were not observed.

*Conclusions and Discussion.*—The G-tolerance limits of 26-31 G in this study are considerably higher than the previous record of 15 G in the prone position on a centrifuge. The limits of tolerance in previous studies were set by eye or leg pain in this position. Water submersion protected against these effects. New limits of tolerance in the prone position seem likely to be in terms of frontal sinus pain and abdominal pain.

In general, while water submersion together with respiratory system pressurization seems to yield a considerable increase in G-tolerance, there are still problems associated with the gas-filled spaces of the body as indicated by the frontal sinus pain with bleeding, and the abdominal pain in the prone position and by the air translocation in the positive G position.

## SUMMARY

Model studies are discussed concerning mechanical principles thought to be important in solving some problems of protection against high accelerations. Also discussed are (1) a study of the effects of acceleration on humans in the positive G (+G<sub>z</sub>) position when submerged to eye level in a tank of water. Breath holding permitted water pressure to increase the air pressure in the respiratory system of these subjects, and (2) subjects were studied in the prone position (—G<sub>x</sub>) while completely submerged with respiratory pressurization.

One subject's tolerance was increased by 13 G in the positive G position and by 15 G in

the prone position. Other subjects showed unusually high G-tolerance in these positions. Undesirable effects had to do with translocation of air headward with the subjects in the positive G position and with bleeding and pain in the frontal sinuses and abdominal pain when the subjects were in the prone position.

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# Isolation, Confinement and Related Stress Situations

## Some Cautions

RICHARD H. WALTERS, Ph.D. and G. BRUCE HENNING

**T**HIS paper was prompted by a recent bibliography by Weybrew and Parker<sup>44</sup> which listed publications related to sensory deprivation, isolation, and confinement. The bibliography, although extremely useful, reflects a current tendency to assume that sensory deprivation studies may supply the answer to a whole set of applied problems including those of space flight, submarine warfare, imprisonment, psychological reaction to sensory deficiencies, enforced indoctrination, life on isolated service stations, and the etiology of mental illness. A similar trend is reflected in three symposia sponsored by the Group for the Advancement of Psychiatry.<sup>14-16</sup> A little thought will show that hasty extrapolation of findings from sensory deprivation studies is dangerous and unwarranted.

Most sensory deprivation studies with human subjects have involved exposing the participants to a much greater degree of social isolation than occurs during a comparable period of a man's life. Thus, the effects of sensory deprivation and social isolation have been inextricably confounded. Moreover, it is possible to conceive of situations—some of them associated with the real-life problems to which these research findings have been applied—which provide a wealth of novel sensory input but little opportunity for social contact. Solitary travel and space flight may be situations of this kind. Some of the effects attributed to sensory deprivation are probably more closely related to fear of aban-

donment, or of being unable to cope with a situation single-handed with little or no hope of assistance, than to any lack of sensory input. Some of the relevant autobiographical material<sup>28,36</sup> strongly suggests that, for much of their time, the authors were not faced with a physically monotonous environment.

The effects of social isolation *per se* have received relatively little attention in controlled experimental settings. Most of the relevant studies<sup>1,8,9,39-42,46</sup> have necessarily involved some degree of sensory deprivation through confining subjects to a single room and depriving them of the sensory experiences associated with seeing, touching, and conversing with other people. They have, however, focused on the effects of social isolation and have involved few restrictions on the vision, hearing, or movements of the subjects. Other studies<sup>7,31,32,37</sup> have investigated affiliative responses in anxiety-arousing circumstances on the assumption that avoidance of isolation is a function of anxiety about, or fear of, being alone when pain or danger threatens. In only one study<sup>6</sup> has social isolation been systematically used as a control condition in an attempt to determine some of the effects of sensory deprivation.

Many of the real-life situations to which extrapolation from sensory deprivation studies has been made are experienced not by individuals acting alone but by small groups of men who are compelled to live together with few outside contacts for a limited period of time. This is true, for example, of servicemen placed on isolated stations and of air and underwater crews. While findings concerning social isolation may be relevant to the understanding of

From the Department of Psychology, University of Toronto, Toronto, Canada.

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their problems, some of their responses can perhaps be better understood in terms of the social processes that typically occur within small groups. The social process theories of Festinger<sup>4,5</sup> and Schachter<sup>32</sup> and the studies of communication and persuasibility of Hovland and his co-workers<sup>20-22</sup> are probably more relevant to such situations than are the neurophysiological theories of Walter<sup>38</sup> and Hebb.<sup>18</sup> Theories concerning social processes are probably also important for the understanding of the phenomena associated with enforced indoctrination ("brainwashing").

With reference to these latter phenomena, it should be noted that a breakdown of social communication sometimes occurs in the presence of other people. Schein,<sup>33</sup> for example, describes procedures used by communist captors that were aimed at making each prisoner suspicious and fearful of his fellows, thus leading to "isolation" of the group members. The psychological reaction of the prisoners may, in some cases, have been not unlike those attributed by some authors<sup>3,26</sup> to incipient schizophrenic individuals.

Some understanding of the effects of prolonged social isolation in real-life situations can probably be gained from studies of isolated communities<sup>24,34</sup> and of children brought up in impoverished environments. It must be remembered, however, that the responses of people who are habituated to such environments are unlikely to parallel those of people who are suddenly deprived of accustomed social and cultural experiences and are faced with unaccustomed dangers. Gladwin,<sup>10</sup> for example, gives an interesting account of canoe travel among the Trukese which shows that their responses to long and hazardous sea journeys are quite different from those attributed to members of highly civilized communities who have experienced comparable situations.

Field and autobiographic studies have indicated that there are wide individual differences in response to the stress situations associated with the hazards of exploration and war. Some of these differences can perhaps be understood

in terms of the different life-histories of the participants and particularly of the social conditioning provided by the child-training techniques of their family, culture, society, and social class. Recent studies have suggested that even the variable of birth-order within the family may be an important determinant of the degree to which an individual fears social isolation and consequently gives way to social pressures from other people.<sup>7,31,32,37</sup>

It would be hazardous to attempt, at our present stage of knowledge, a theoretic integration that would serve equally well to explain current findings concerning sensory deprivation, the various conditions that have been labeled "social isolation," and reactions to living in small isolated groups. One common motivating factor may be termed "response to stress" from a physiologic point of view and "anxiety" from the point of view of the psychiatrist and psychologist. Some psychiatrists, notably Solomon<sup>27,43</sup> and his co-workers, seem well aware of this possibility. The concept of "effectance," recently introduced by White,<sup>45</sup> may be equally important in understanding the phenomena under consideration. By this concept, White means the motivation to master or interact effectively with one's environment. Undoubtedly, anxiety and its physiologic concomitants occur when mastery is threatened, but in their exploration of the physical world and their attempts to control (rather than be controlled by) their environment, human beings may struggle for success even when fear of failure does not threaten them.

Attempts to understand such complex phenomena as responses to space flight and military hazards have, for the most part, been based on the neurophysiologic and psychoanalytic theories used in interpreting laboratory studies of sensory deprivation.<sup>2,13,19</sup> In contrast, recent studies of social isolation have been based on learning theory, particularly on the theories of Hull<sup>23</sup> and Skinner.<sup>35</sup> Premature crystallization of theory could endanger the progress of research in these areas. This progress can probably best be ensured by moving from the

# STRESS SITUATIONS—WALTERS AND HENNING

laboratory to the field and back again from the field to the laboratory. In fact, laboratory studies are undoubtedly of the most immediate practical value when they simulate field conditions—as they do in the studies of Levy, Ruff and Thaler,<sup>25,30</sup> authors who have shown a great deal of sensitivity to the complexity of the problems they investigate. On the other hand, the identification of critical variables can be more easily achieved through a more piecemeal approach. The problem with most sensory deprivation studies is that they have simultaneously manipulated the subjects' physical and social environments without simulating any real-life situation.

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## National Conference on the Peaceful Use of Space

Leaders of science, industry, government and education will meet in Tulsa, Oklahoma, on May 26 and 27 for a national conference devoted exclusively to the peaceful use of space. Mr. Harold Stuart, former Assistant Secretary of the Air Force, is the conference chairman. Co-sponsors of the conference include the Aerospace Medical Association, Aerospace Industries Association of America, American Astronautical Society, American Institute of Biological Sciences, Frontiers of Science Foundation, Electronic Industries Association, and the Institute of Aerospace Sciences.

At the conference NASA's activities in space science will be discussed by leading authorities on lunar, planetary, weather and communications satellites; manned space flight; launch vehicles; nuclear propulsion and life sciences. Senator Robert S. Kerr, Chairman of the Senate Astronautical and Space Science Committee; James E. Webb, Administrator of NASA; and Dr. Lloyd V. Berkner, Chairman of the Space Science Board, National Academy of Sciences, will deliver major addresses at the Tulsa meeting, with other key figures from government, education and industry participating in the two-day meeting.

The conference will be open to all interested persons, and Association members are especially welcome.

# Current Problems in Astroradiobiology

HERMANN J. SCHAEFER, Ph.D.

**H**UMAN FLIGHT in extra-atmospheric regions has created, for the radiobiologist, a number of new problems resulting from the fact that the radiation environment in space is peculiarly different from what natural and man-made terrestrial radiation sources can provide. Already before the advent of the satellite era, when the ceiling of manned aircraft progressed from the troposphere deeply into the stratosphere and finally all the way up to the top of the atmosphere, these new aspects were recognized. Especially one problem has found the early attention of those concerned with radiation hazards in high altitude flight. We mean the controversial issue of the heavy nuclei of the primary cosmic radiation. In 1948, soon after the discovery of the heavy nuclei, C. F. Gell<sup>2</sup> directed attention to the fact that components of the primary cosmic ray beam at extreme altitude and in free space would pose a special problem. Today, twelve years later, the question of the microbeam effectiveness of heavy nuclei is still unsolved. When radiation hazards in space flight are discussed nowadays, the newly discovered high intensity proton radiation fields of various origin are in the center of interest. In fact, attention seems so much concentrated on these new phenomena that the unsolved heavy nuclei problem is in a certain danger of no longer being seen in its true significance. This finds a certain justification in the circumstance that the exposure hazard in proton radiation fields is an acute one which might well reach or surpass the incapacitation threshold, whereas the heavy nuclei hazard is of the low-dosage long-term

type in which the damage develops slowly and at first inconspicuously, yet ultimately might even be more serious in its irreparability.

The radiobiological problems concerning heavy nuclei irradiation have been discussed repeatedly and at length. The present debate, therefore, shall be limited to a few remarks on the methodics of future experimental work. Obviously, it makes a big difference in expenditure of time and money whether studies with biological specimens are carried out with balloons or space platforms in the region of the primary radiation or with simulated microbeams or artificially accelerated heavy ions in ground-based laboratories. It seems of interest, then, to review critically presently existing capabilities in latter respect. Artificially accelerated heavy nuclei have been successfully produced with the Heavy Ion Linear Accelerators (HILAC) of the radiation laboratories at Berkeley and Yale. The latest state of the art as reported by Heckman and colleagues<sup>3</sup> is that nuclei of carbon, nitrogen, oxygen, neon, and argon can be accelerated to a maximum kinetic energy of 10 Mev per nucleon. In terms of argon ions, this means a maximum kinetic energy of 400 Mev. While this is unquestionably a very impressive accomplishment opening new avenues for significant experimental work on the complex problem of the RBE (relative biological effectiveness) of densely ionizing radiations, it still is of interest in the present context to compare these artificial heavy nuclei to those of the primary cosmic radiation. Figure 1 shows a montage of micrographs of two heavy nuclei, one a calcium nucleus of the primary cosmic ray beam and the other an argon track from the HILAC as published by Heckman and his co-workers. Both tracks have been recorded

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with the same nuclear emulsion (Ilford G-5) and are shown at the same magnification. Since the atomic numbers (Ca:20, Ar:18) differ only slightly, the nuclei can be considered very similar.

transmits to the secondary electrons a correspondingly higher speed, *i.e.*, range. This poses the question whether two different densely ionizing particles, which have the same LET (linear energy transfer, usually quoted in ion

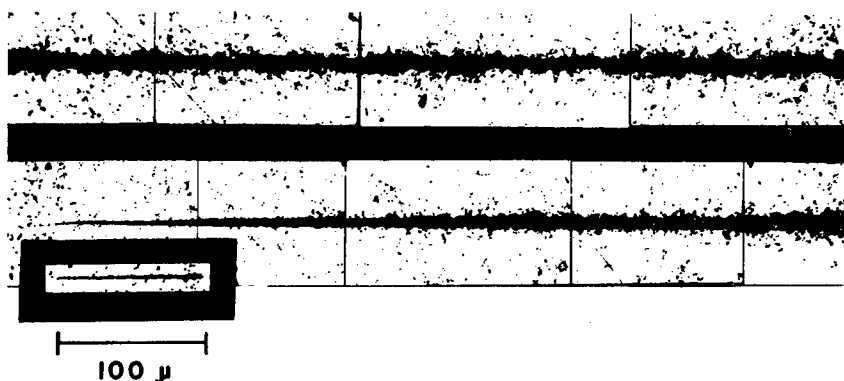


Fig. 1. Terminal Sections of Heavy Nuclei Tracks. Large track, broken in two sections, is Calcium ( $Z=20$ ) track of primary cosmic radiation. Short track in inset at lower left is Argon ( $Z=18$ ) track of HILAC. Both tracks are shown at same magnification. (Heckman et al.,<sup>3</sup> Fig. 13, p. 555.)

In comparing the two tracks (Fig. 1) from a radiobiological viewpoint, two magnitudes have to be distinguished because they have a different meaning for the biological effects. These are the longitudinal and the radial extension of the two tracks. The former, the longitudinal extension, is strikingly greater for the cosmic ray nucleus indicating the much larger energy and range of the incident particle. Yet this circumstance seems only of secondary importance as far as the basic problem of the microbeam effectiveness of the nucleus on the structure of a single cell of living tissue is concerned. For this latter question, the radial spread of the ionization column is the decisive magnitude. For densely ionizing radiations from laboratory sources, such as protons, alpha rays, or fission recoil nuclei, the diameter of the ionization column is of the order of a few tenths of a micron. That means it is much smaller than the living cell. For the heavy nuclei of the primary cosmic ray beam, the diameter of the ionization column reaches the full size of a living cell due to the much higher speed of the nuclei, which in turn

pairs per micron tissue), yet show a large difference in the radial spread of the ionization events about the center of the track, would produce the same damage in a living cell.

Unfortunately, present understanding of the primary biochemical changes released in the chromosomal material of a cell by ionization events is so poor that any specific inductive reasoning as to the possible significance of a different radial spread of these events seems out of reach. Merely a more general approach could be attempted with the following argument. Some lines of experimental evidence indicate that a large part of the radiation damage to cellular material originates from intermediate substances formed from water. These intermediate substances are radicals such as  $H$ ,  $OH$ ,  $HO_2$ ,  $H_2O_2$ , and, if organic molecules are in close vicinity, also organic peroxides. If this is true, the zone of primary damage can be expected to be larger than the region to which the ionization events are limited because of the diffusion of the radicals in the cellular material. Since the lifetime of free radicals is extremely short, the diffusion length

is also extremely small. Zirkle and Tobias<sup>6</sup> were the first ones to attempt a quantitative treatment of the kinetics involved. Others have resumed and further contributed to this discussion. A list of references is contained in

in ground-based studies alone, an inspection of the dimensions of the HILAC track (Fig. 2) clearly indicates that it has the definite capability of contributing toward such a solution. It can be seen (Fig. 2) that the HILAC

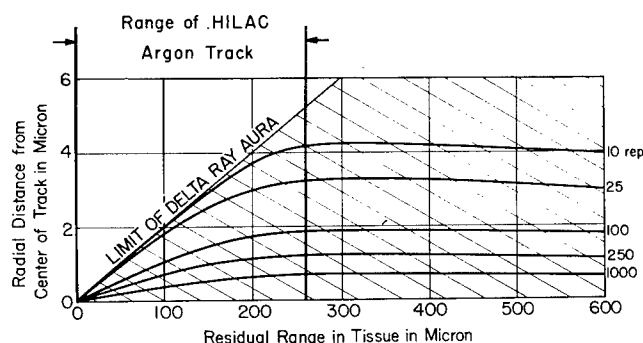


Fig. 2. Microstructure of Ionization Column in Tissue for Tracks Shown in Figure 1. Range of HILAC Argon track in tissue is 260 microns since stopping power of tissue is smaller than of nuclear emulsion. Note large radial spread in high energy section of HILAC track.

Hutchinson's<sup>4</sup> study. In the present context, the estimates of the diffusion length are of special interest. They range (Hutchinson) from 30 to several hundred Angstrom Units ( $1 \text{ \AA} = 10^{-7} \text{ millimeter} = 10^{-4} \text{ micron}$ ). Figure 2 depicts in graphical form the dosage field of the terminal section for the Calcium nucleus of Figure 1. Superimposing upon this field the diffusion lengths for the radicals one sees that the tissue volume in which the primary processes occur is enlarged only very little. That means that the basic difference in the radial pattern of the ionization column between cosmic ray heavy nuclei and densely ionizing particle radiations from terrestrial sources should be fully reflected in the corresponding pattern for the primary chemical action. The conclusion, then, that two ionizing particles of the same LET, yet of different radial spread of the energy dissipation will produce the same damage in centrally traversed cells appears to stand on shaky grounds and in great need of experimental testing.

Though it seems questionable that a full solution of this problem could be accomplished

argon tracks enter the target with a radial spread of about 10 microns diameter for the 10 rep level. That is entirely the order of magnitude of cosmic ray heavy nuclei and distinguishes the HILAC quite basically from other laboratory sources of densely ionizing radiations. Of special interest in experimental studies with artificially accelerated heavy ions would be the range of low dosages down to the level of single traversals. This would directly bear on the cosmic ray heavy nuclei problem. To what extent the results of such experiments would be representative for the wide spectrum of heavy primaries, is of course, a complex question. Especially the so-called superheavy nuclei, *i.e.*, nuclei heavier than iron which have been recorded repeatedly with rockets in the primary beam entirely outside the atmosphere, should be considered in this respect. They are bound to gain importance for extended exposures of human beings at satellite altitudes and beyond.

As mentioned earlier, the discussion of radiation hazards in space flight centers at present very heavily on the newly discovered various

proton radiation fields in space. Among them, those produced by solar flares seem potentially the most dangerous. Disquieting is the fact that such events apparently are more frequent than has been assumed in the past, when only flare observations, but no cosmic ray recordings were available. Observations during 1959 in particular indicate that almost twice a month a greatly enhanced proton intensity prevails in interplanetary space as a direct consequence of flare activity on the sun.

In view of the assumption that in the near future, manned space flight will be limited to ballistic and orbital flights of shorter duration at satellite altitudes, it seems of interest to investigate what time reserve exists for starting re-entry procedures if a larger flare occurs while such a mission is in progress. The first clues of a flare in progress available on the earth are the visible observation of the flare and the increased noise level in long range radio communications. The latter is caused by ionization in the ionosphere produced by the enhanced ultraviolet intensity from the flare. This phenomenon is particularly disturbing for the commercial wireless service. These people, therefore, have been repeatedly the first ones to announce that a large flare was in progress. Both clues, visual observation and increased ultraviolet, arrive with the speed of light whereas the flare-produced protons travel at lower speeds depending on their energies. It seems of interest to evaluate this time lag for the various spectral regions of the flare-produced protons. Figure 3 shows the results of this evaluation. The abscissae of both graphs show kinetic energy in identical scales. The ordinate of the upper graph shows at the left proton speed in fractions of the speed of light  $c$  and at the right the corresponding delay in minutes with which protons would arrive at the earth behind a signal from the sun travelling at full  $c$ . The ordinate of the lower graph shows a typical integral energy spectrum of flare-produced protons compiled by Bailey<sup>1</sup> from data of various experimenters. It is seen that indeed a substantial time reserve exists for precisely that

section of the energy spectrum which contributes the bulk of the additional intensity.

It should be emphasized that the assumption of a straight-line travel of solar protons from the sun to the earth holds only for a certain fraction of the flare-produced flux. The dynamics of interplanetary hydrogen plasma under the influence of solar activity is as yet incompletely understood since only the satellite era opened the way for direct measurements in deep space. According to present concepts, two acceleration mechanisms for solar protons have to be distinguished. One is acting in the flare itself. These protons, then, would travel the full distance from the sun to the earth essentially at the same high speed. The other mechanism is acting far away from the sun in the turbulent magnetic fields of the "solar wind." This very descriptive term has been suggested by Parker for the phenomenon of the coronal plasma expanding into interplanetary space. The plasma clouds move in a turbulent fashion at convective speeds of about 1000 km/sec. Due to the turbulence, plasma clouds create and carry their own magnetic fields which in turn exert accelerating influences on the hydrogen ions in the clouds. Obviously, the basic time-of-flight relationships underlying Figures 3 and 4 do not hold for protons accelerated by this mechanism. As these protons have travelled a shorter or longer fraction of the full distance from the sun at the low speed of the solar wind and have been accelerated gradually along tortuous trajectories in turbulent fields, they arrive at the earth with a delay of many hours or even of one or two days behind the visible light from the flare.

To be sure, magnetic deflection is acting also on the flare-accelerated protons. It was mentioned above that the concept of straight-line motion underlying the computations for Figures 3 and 4 holds only for a certain fraction of them, namely, those which make up the initial surge of the proton intensity during a flare. Other fractions seem to reach the earth in a more indirect way causing the



proton intensity to remain elevated over a much longer period than the actual visible flare activity on the sun. Strong evidence for this proposition is offered by the fact that

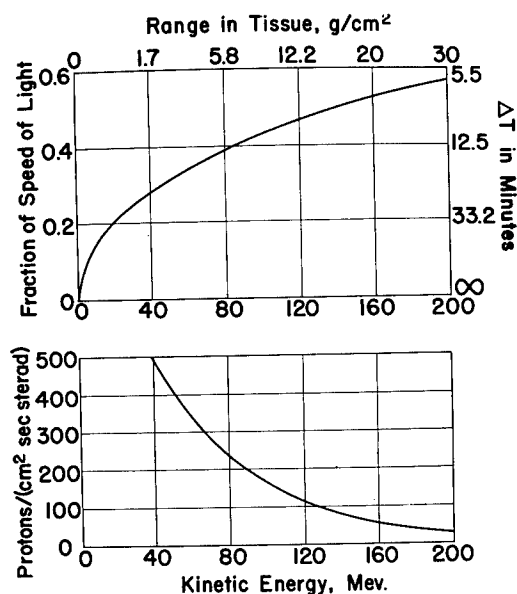


Fig. 3. Time of Flight of Solar Protons. Upper graph shows speed (left ordinate) and delay of arrival at earth behind light (right ordinate) as a function of kinetic energy. Lower graph shows integral energy spectrum of flare-produced protons. Note longer delays for larger particle intensities.

the instantaneous proton radiation during the large flare of February 1956 has reached the night side of the earth. During this flare, the sun was in the zenith over the northwestern edge of the Australian continent, yet all cosmic ray monitoring stations in the Western world, in Europe as well as in both Americas, experienced strong increases in "cosmic ray" intensity. Figure 6 shows an account of the sequence of events. The graph shows the cosmic ray surge at a station on the day side (Cape Schmidt) and on the far side (Ottawa) of the earth. It is interesting to notice that the steepness of onset as well as the peakedness and time of occurrence of the maximum differ considerably for the two locations.

The phenomenon that the total flare-produced proton flux at the earth is spread over

a considerably larger time interval than the flare activity on the sun provides an additional time reserve for the re-entry of a space vehicle which wants to escape or minimize radiation exposure. Judged by the sea level neutron intensity, which can be shown to be a true measure of the extra-atmospheric intensity of

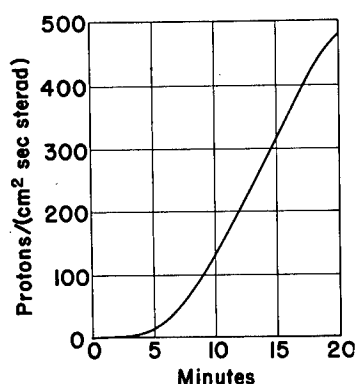


Fig. 4. Time of Flight of Solar Protons. Rise of Proton Intensity of Direct Beam of Spectral Type Shown in Figure 3. Assumed is essentially straight-line travel. Zero Time: Light from onset of flare arrives at earth.

ionizing particles, the integral exposure from the time of the beginning of the proton surge builds up as shown in Figure 5. The graph is based on observations of the sea level neutron intensity during and after the 1956 flare at Durham, New Hampshire. It is seen that even if a full hour has elapsed before a manned space vehicle has completed re-entry and is back behind the shield of the atmosphere, a substantial reduction of the integral dose would still be accomplished. Referring again to Figure 6, it can also be seen that this time reserve is markedly smaller at longitudes closer to the direct impact zone. In addition to that, a strong latitude effect also seems to exist for both the rise time and the integral dose. Yet a complete account of these relationships is beyond the scope of this treatise.

It is a very complex task to express all the new data on flare-produced proton beams in

space in terms of tissue depth doses in an exposed human target. The old problem of medical dosimetry, a separate and accurate evaluation of "air" dose, tissue dose, and depth

ton fluxes in space differs quite basically from that for terrestrial proton fields, such as resulting from reactor neutrons. For the details, the reader is referred to the earlier treatise.

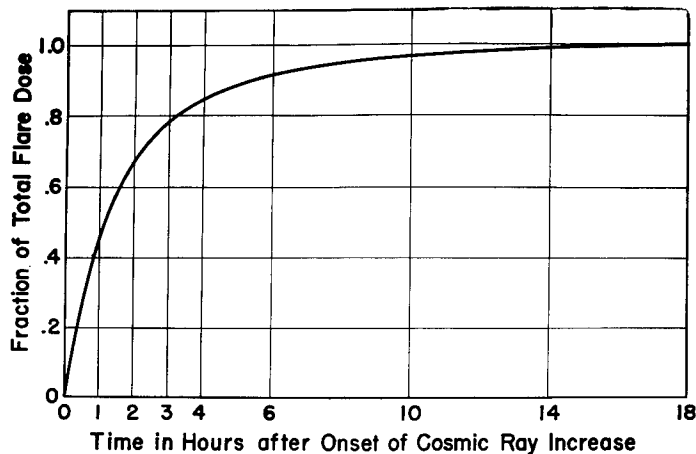


Fig. 5. Accumulation of Integral Extra-Atmospheric Flare Dose During and After Giant Solar Flare of February 23, 1956.

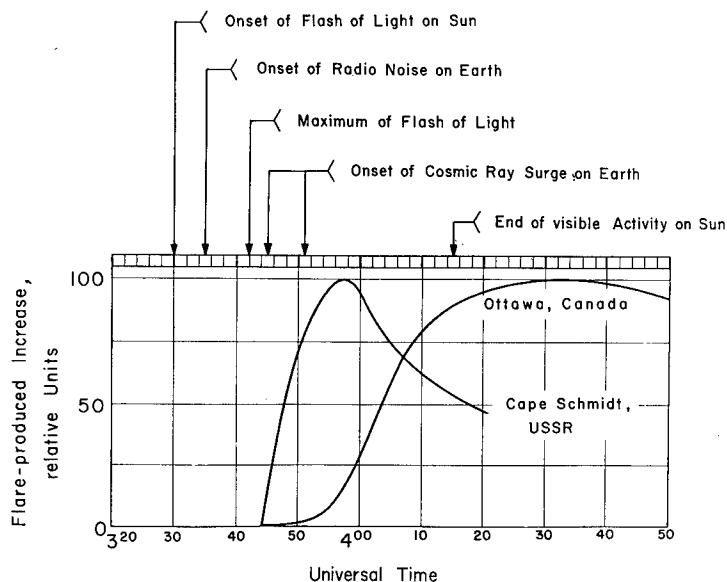


Fig. 6. Sequence of Events and Surge of "Cosmic Ray" Intensity for Giant Solar Flare of February 23, 1956. Note slower onset and longer protraction of surge on night side of earth (Ottawa).

dose is encountered again. These aspects have been discussed elsewhere.<sup>5</sup> It has been shown that the intratarget dosage distribution for pro-

The radiation hazard presents itself indeed as a major obstacle for man's venture into space. The particular challenge rests in the unpredict-

ability and the everchanging conditions with regard to time and location of high intensity proton fluxes. While for an earth-circling satellite it seems safe to state that the radiation hazard will not be an insurmountable impasse, quite serious doubts must be voiced as far as manned missions deeper into space are concerned.

## SUMMARY

Twelve years after the discovery of the heavy nuclei of primary cosmic radiation, the mode of action of this type of densely ionizing radiation on living matter is still essentially unknown. Inferences from other radiations with a high rate of energy dissipation have not been conclusive heretofore because the micro-structure of the ionization columns differs too much from that of cosmic ray heavy primaries. A first break in this deadlock seems accomplished by the recently reached energy levels of the HILAC (Heavy Ion Linear Accelerator). A detailed analysis of the diameter of the ionization column of HILAC Argon tracks shows that the large radial spread of cosmic ray heavy nuclei is for the first time well simulated by a laboratory source. Though with regard to the depth of penetration still much seems left to be desired, the basic question of the microbeam effectiveness of heavy nuclei seems now accessible to laboratory studies.

The discussion of radiation hazards in space flight centers at present upon the newly discovered proton radiation fields of various origin

in space. The greatly enhanced proton flux during and after large solar flares is of special concern. It seems of interest to investigate the time reserve that exists for re-entry behind the shield of the atmosphere after the onset of a large flare on the sun. Comparing the time of flight for a typical flare-produced proton spectrum to the speed of light and studying the data on the impact zones for the giant solar flare of February 23, 1956, shows that the grace period is of the order of fifteen to forty minutes. It depends in a complex manner on latitude and longitude of position relative to the sun and on the compromise of how much of the initial steep surge of the extra-atmospheric radiation intensity one wants to accept.

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### "The Dark Fence": Radar Screen Detects Orbiting Objects

The Navy has announced that the so-called "dark fence" will be completed later this year. It has been in partial operation for some months.

The screen will be created by a 500,000-watt transmitter (three smaller transmitters are now in operation) emitting a broad, thin radio curtain across the continent from southern California to Georgia. Reflections of objects in near space are picked up by gigantic receiver arrays. Data are fed into computers, and the orbits can be calculated. The system makes it possible to detect and track nonradiating satellites passing over this country. Navy officials said that even in its present partially completed form the system has detected and tracked a piece of wire 15 feet long orbiting at a height of 400 miles. The wire was debris from U. S. satellite.—*Science*, March 3, 1961.

## Considerations for Special Instrument Flight Training to Minimize Spatial Disorientation

HEINZ VON DIRINGSHOFEN, M.D.

**I**N GENERAL, it is not customary to make suggestions for flight training at a congress of aviation medicine, when their value to flying safety has not yet been shown. I am going to do this however, because I would like to present for discussion a particularly important problem in the training of pilots for high speed aircraft. The problem is the unlimited control of the aircraft during instrument flight. We must consider, that in future combat flying, the direct view of the external world will be forced more and more into the background and the instrument panel will move more and more to the fore. This is valid for the control of the aircraft, as well as for the observation of an external object. In the future, instrument flight will be the usual and visual flight the exceptional. Moreover, instrument flight situations will appear more frequently which are acrobatic in character. I am thinking particularly of steep climbs, half rolls about the longitudinal axis of the aircraft, leveling off with high radial acceleration and finally, flight conditions with subnormal gravitational attraction or complete weightlessness.

At the present time combat flying is often a combination of visual flight and instrument flight. This combination is one of the main causes of spatial disorientation and vertigo. With the development of jet aircraft, these disturbances have become a serious problem in combat flight. Statistics of the United States Air Research and Development Command show that probably 14 per cent of fatal aircraft accidents can be attributed to spatial disorientation and vertigo. Disturbances of spatial orientation

appear frequently during the transition from visual flight in formation to instrument flight. A catastrophe during this transition can almost always be traced to pilot error. That is, he was insufficiently trained to control his aircraft in positions and situations which were abnormal for instrument flight.

The danger has become greater with the increase in speed of jet aircraft: a situation in which one gets into unforeseen difficult instrument conditions while the time for transition to a secure instrument flight is decreased.

This problem could be solved only partially by an automatic pilot which would take the aircraft out of every situation into a non-critical position. However, it would hardly be advisable for one to leave himself completely in the hands of such a robot. It would therefore certainly be desirable to give the pilot the possibility of controlling the aircraft in every situation, including blind flight, by means of an artificial horizon which is unlimited for all movements in space and, at the same time, train the pilot accordingly.

In the future such special instrument training should become standard procedure in flight training just as certain acrobatic maneuvers in visual flight presently are. If the instructor were to stress the importance of the transition from visual flight to instrument flight and at the same time force the cadet into flying situations where he suffers from spatial disorientation and dizziness, it is highly probable that we could substantially reduce the number of accidents resulting from spatial disorientation and vertigo. The observation of the cadet during his training is certainly more illuminating than a battery of tests in the laboratory.

Presented at the European Congress of Aviation Medicine, London, England, August 30, 1960.

## SPACIAL DISORIENTATION—VON DIRINGSHOFEN

Since it is always more expensive, both in time and money, and therefore more difficult to train a specialist in aviation medicine who is a rated jet pilot, there is an ever increasing inclination to judge the aptitude of a pilot on the basis of psychological and physiological laboratory tests. The scientific value of these tests will in no way be negated but the development of laboratory tests should not serve to divert attention from the observation of the flight cadet and pilot under actual flight conditions. Thus, actual observation during flight and expert evaluation of aircraft accidents will afford the proper scale for good judgment regarding the problem of spatial disorientation and vertigo in practical aviation medicine.

For a special instrument flight training program to embrace all combat conditions, the artificial horizon must fulfill the following conditions: (1) It must be completely "Kunstflugtauglich" (adaptable to acrobatics) and therefore insensitive to accelerations. (2) It must be so obvious that its interpretation and utilization by the pilot with adequate training follows without further thought, that is, as a reflex act.

We must still decide which is best for this purpose: (1) representation of the horizon with respect to the aircraft, (2) the condition of the aircraft with respect to the horizon, or (3) a combination of both. Since the standard compass is no longer usable during a nearly vertical climb or dive, we must at least have north or a preselected flight path readable directly on the artificial horizon.

Regarding warning signals to avoid dangerous flight situations I wish to suggest placing a source of vibration of approximately 50 cycles per second into the hand grip of the control stick. As the aircraft approached a critical situation, for example a critical mach number, a critical angle of attack or a critical radial acceleration, the pilot would feel the distinct vibration. It would not be great enough to

disturb the finesse of his flying but would be enough to warn him of the situation.

Obviously if adequate blind flying instruments, fully adapted for acrobatics, were available, it would not be very difficult to establish a special instrument training program in which the instructor could instill enough confidence in the cadet that he would be certain he could quickly correct the orientation into a normal flight pattern under instrument as well as under visual conditions.

When adequate training vehicles exist, it will also be possible to practice recovery from spins. Twenty-five years ago I could fly a light plane out of a spin of almost two seconds per revolution with my eyes closed. Unfortunately to recover from a dive and resume horizontal flight, I had to see the actual horizon. This was so, because the existing blind flying instruments were not suitable for the purpose. From personal experience I do not think excessive training would be necessary to train an advanced cadet to the point where he can control his aircraft by instruments as well as by visual flight if a good earth horizon instrument were available.

For preliminary training and in order to accustom the cadet to help subdue the dizziness phenomena we must consider three-dimensional flight-simulators and other instruments which give the sensation of three-dimensional motion such as those suggested by Bending.<sup>1</sup> The more the pilot learns to subdue disturbing sensations during instrument flight or at least not to pay attention to them, the fewer will be the number of aircraft accidents caused by dizziness. The dizziness attending subgravity or weightlessness in space flight may well be a problem in the future.

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## President's Page

### *Aerospace Medical Association*



ADMIRAL J. L. HOLLAND

The Chicago meeting of the Aerospace Medical Association is now history. It will long be remembered, however, as one of the finest meetings in the thirty-two-year history of our Association. Credit for this goes to many, and the list is headed by our immediate Past President, Dr. G. J. Kidera, and his able General Chairman for the meeting, Dr. J. N. Waggoner.

At the close of the meeting, President-elect Rear Admiral James L. Holland, MC, U. S. Navy, was installed as the thirty-first President of the Association to serve through the meeting to be held in Atlantic City in April, 1962.

Admiral Holland has been active in the affairs of the Association for the past fifteen years, having served on various committees and the Executive Council and the Executive Committee. He is a Diplomate of the American Board of Preventive Medicine and a Fellow of the American College of Preventive Medicine.

Admiral Holland received his B.A. and B.S. degrees from the University of Mississippi and his M.D. degree at Vanderbilt University. He entered the Medical Corps of the U. S. Navy upon graduation in 1930. Since then, he has served in various naval hospitals, shore activities and ships at sea. He was designated a Naval Flight Surgeon in 1943 and has devoted his efforts since to the advancement of the specialty of Aviation Medicine. He was the Director of the Division of Aviation Medicine in the Bureau of Medicine and Surgery, Navy Department, 1950-52, and Commanding Officer of the School of Aviation Medicine, Pensacola, Florida, 1952-54. Currently, he is Commanding Officer of the Naval Aviation Medical Center, Pensacola.

Admiral Holland brings to the Association as President a varied and distinguished career which will be an assist to him and to the Association during his tenure of office.

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# Aerospace Medical News

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## The International Academy of Aviation Medicine

The International Academy of Aviation Medicine, which replaces the International Board of Aviation Medicine, Incorporated, has recently published a brochure containing a brief introduction and history of the association, its constitution, and conditions of eligibility for membership. Since this will be of some interest to a number of our members, we are taking this opportunity to summarize here some of the central points contained in this brochure.

**Introduction and History.** One of the fastest growing medical specialties is aviation medicine, the Academy notes, and today nearly every country has either an existing aviation medical society or specialists who are members of such societies in other countries. In order to promote aviation medicine on a world-wide basis, and to contribute to the elimination of difficulties in this field on the international level, the Academy was created. Designed to be an organization which is acceptable to all countries, this association hopes to establish election to membership as an international standard for professional competency in the field of aviation medicine. Because its membership will be small, the Academy does not foresee any displacement of existing societies; rather, it "will attempt to be the cohesive force to draw them together."

**Constitution.** The constitution of the Academy, which was drafted by a small Founders' Group of selected individuals from most of the countries having major activities in aviation medicine, provides that the legal seat of the association shall be Brussels, Belgium. The objectives of the association are: "(i) to promote the development of science and to foster research in the realm of biology, aviation and space medicine; (ii) to help to improve and develop the exchange of information and ideas in all these fields; (iii) to contribute to the search for new knowledge and its practical scientific application; (iv) to improve the teaching of these sciences and their corollaries and to foster the training of experts in aviation and space medicine; and (v) to facilitate international co-operation and relations among persons dedicated to such co-operation." To achieve these goals the Academy will organize conferences and study groups; present its views on aviation medicine to international governmental and non-governmental groups; establish re-

gional commissions, study groups and any other committees which may prove necessary; and sponsor investigations, research and publications.

The Academy is composed of the General Assembly, the Council, the Selection Committee, and the commissions and other committees which may be established by the Council. The General Assembly consists of all the members and associate members, and must meet at least once each two years. The Council, which acts with full administrative, executive and financial powers between meetings of the General Assembly, consists of at least a President, a Vice-President, a Secretary General and four directors. Provision is made for the subsequent appointment of two additional Vice-Presidents, a Chancellor, and a Treasurer. The Selection Committee is composed of a Chancellor and of twenty persons selected by the General Assembly from its members for a term of eight years.

**Conditions of Eligibility.** Members shall be nominated by the Selection Committee and must be approved by a two-thirds majority of the Selectors. The principal requirements for membership, which is limited to two hundred, are that the applicant must be over forty, a doctor in medicine qualified to practice in the country of graduation, and must give evidence of more than ten years specialization in the field of aviation medicine. Provision is also made for the election of fifty associate members, who must fulfill the same conditions as members except that the doctorate in medicine may be replaced by another doctorate or equivalent scientific title in a related field. Inquiries for complete details concerning eligibility for admission and all applications for membership should be addressed to the Secretary-General, Palais d'Egmont, 8, place du Petit Sablon, Brussels, Belgium.

## President Kennedy Sends Greetings

Dear Doctor Kidera:

Since I am unable to be present at the 32nd Annual Scientific Meeting of the Aerospace Medical Association, please give my greetings to all in attendance, including the many international guests and participants.

Your program illustrates the complexity and breadth of scientific investigation going forward in civilian, commercial and military aviation and space exploration. I am gratified by this evidence of the combined effort of the allied biomedical disciplines leading to continued national progress in these vital areas.

Certainly, now more than ever before, advances in all aspects of aerospace research and flight safety are of great concern for us all, and your conference promises to contribute significantly to the expansion of our space frontiers.

Please accept my best wishes for a most successful meeting.

Sincerely,

(signed) J. F. KENNEDY

## Space Science Board Forms New Committees

Shortly after establishment of the Office of Life Sciences Programs by National Aeronautics and Space Administration in March, 1960, steps were taken within the National Academy of Sciences to merge activities of the Armed Forces-National Research Council Committee on Bio-Astronautics with those of the Space Science Board. This merger, which was recently completed with the phasing out of the Bio-Astronautics Committee, affords a means of enlarging the services of the Academy beyond those to the Army, Navy and Air Force, as conceived in the charter of the Bio-Astronautics Committee. The newly created Office of Bio-Astronautics in the Department of Defense, the National Science Foundation, and the Office of Life Sciences of NASA, as well as the Armed Forces, are served by the Space Science Board.

To implement the increasing role of the Space Science Board, three new committees have been formed to assume the responsibilities which were formerly the function of the Bio-Astronautics Committee. These functions are in three broad fields: advisory, technical assistance, and the conduct of forums or symposia. All policy matters are referred to the SSB. The three new committees are:

**The Man in Space Committee** is chaired by Dr. C. J. Lambertsen of the University of Pennsylvania and will concern itself with both minimum protection and safeguards of a short-range "man-in-space" program as well as the planning of experimental programs in the life sciences to support more sophisticated, long-term exposure of man in the space environment. In connection with this program the committee will study life support systems; long-term confinement; procedures for monitoring the performance and physical condition of occupants of spacecraft; and the potential usefulness of man for monitoring, correcting and maintaining on board-equipment

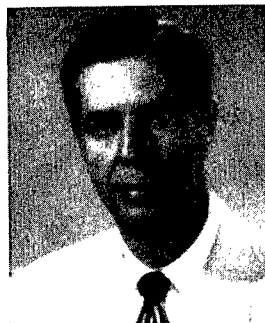
**The Committee on Exobiology.** Chaired by Dr. Joshua Lederberg of Stanford University and including several members of the former Panel on Extra-Terrestrial Life, this committee will be concerned with a search for evidence to indicate extraterrestrial forms of life, past or present; develop experimental approaches for detecting extraterrestrial life forms; monitor sterilization procedures for space probes; and investigate the problems of back contamination. It will also encourage operational agencies in pursuing promising applied programs.

**The Committee on Environmental Biology,** under the chairmanship of Dr. Colin S. Pittendrigh of Princeton University, will formulate requirements for biological payloads in space vehicles and assess the adequacy of present ability to satisfy those requirements. The committee will be concerned with such matters as closed ecology, radiation effects on lower organisms, use of space as an environment to classify known biological problems and to detect unsuspected inputs into living systems.



## CAMA President

Dr. Thomas A. Coates, of St. Louis, Missouri, becomes the new president of the Civil Aviation Medical Association. He succeeds Dr. Delbert F. Rey, who served as president during 1960-61.

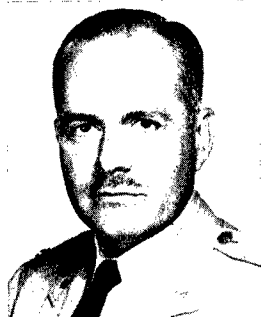


DOCTOR COATES  
President, CAMA

Doctor Coates has been in private practice in St. Louis since 1940. Following his graduation from the St. Louis University School of Medicine in 1936 he spent his internship and surgical residency in St. Louis City Hospital and St. John's Hospital, also in St. Louis. After entering private practice in St. Louis in 1940, Doctor Coates became Medical Director of the Curtiss Wright Corporation in Louisville, Kentucky, in 1942. In 1943, he volunteered for duty with the Navy, where he served until 1946. Following his discharge, he re-entered private practice in St. Louis. A Designated Medical Examiner since 1952, Doctor Coates served on the Executive Council of the Aerospace Medical Association from 1959 to 1961.

## New President for Space Medicine Branch

Colonel John M. Talbot, USAF (MC), the new president of the Space Medicine Branch, is a Fellow in the Aerospace Medical Association. He was certified in the specialty of Aviation Medicine by the American Board of Preventive Medicine in 1954. A rated Chief Flight Surgeon, Colonel Talbot received his B.A. and M.D. degrees from the University of Oregon and is a graduate of the USAF School of Aviation Medicine, the Carlisle Medical Field Service School, and the Army Command and General Staff School. His post-WW



COLONEL TALBOT  
President, Space Medicine Branch

II graduate education includes a one-year course in medical physics at the University of California.

Colonel Talbot commenced his military career in July 1939 and, since October 1940, has devoted his

career to aviation medicine and research. His principal assignments have been with the Eighth Air Force in Europe during WW II; ten months with Joint Task Force I and Operation Crossroads; and four years as the head of the radiobiology and biophysics research and teaching program at the School of Aviation Medicine. From the fall of 1951 until September 1956, he was assigned to the Human Factors Research Division, Hqs., Air Research and Development Command. For the next three years, he commanded the 7112th Central Medical Group in Wiesbaden, Germany. He is currently the Chief of the Biological and Medical Sciences Division, Office of the Director of Defense Research and Engineering, U. S. Department of Defense.

## President, Airline Medical Directors Association

Dr. Charles C. Gullett, who has been acting president since the untimely death of Dr. Armand Robert, has taken over the presidency of the Airline Medical Directors Association for 1961-62. He has been Director of Medical Services for Trans World Airlines since 1958 previously having been a member of TWA medical staff for eight years. He is also presently Medical Advisor for Ethiopian Airlines and Saudi Arabian Airlines. Military service included two years each in the U. S. Army and the U. S. Air Force.

Doctor Gullett received his B.S. and his M.D. from Indiana University and is also a graduate of the USAF



DOCTOR GULLETT  
President, Airline Medical Directors Association

School of Aviation Medicine. Active in the Aerospace Medical Association, he has served on the Scientific Program Committee, the Awards Committee, the Medical Criteria for Passenger Flying Ad Hoc Committee, and was chairman of the Commercial Flyer and Passenger Sub-Committee. In addition to holding several positions and offices in county and state medical societies, Doctor Gullett has also served on the CAB Human Factors Team on aircraft crash investigation. Doctor Gullett, the recipient of the Austerman Award, is the author of several scientific papers, articles and research projects in aviation medicine, and a regular weekly contributor to *Greater Kansas Medical Bulletin* on Aviation and Industrial Medicine.

## General Bohannon Relieves General Cullen as Deputy Surgeon General

Major General Richard L. Bohannon will replace Major General John K. Cullen as Deputy Surgeon General of the Air Force in June. General Bohannon,



GENERAL BOHANNON

who comes to his new assignment from three years of duty as head Air Force surgeon with the Pacific Air Forces, is a Chief Flight Surgeon with more than twenty-five years of active duty in the Air Force. As top USAF medical officer in the Pacific/Far East Area, General Bohannon supervised the operation and administration of 14 Air Force hospitals and

dispensaries at bases throughout Japan, Korea, Okinawa, Taiwan, and the Philippines, serving some 100,000 military personnel and dependents.

Acting on the knowledge that disease and death know no national boundaries and that none should be recognized in combatting them, Dr. Bohannon has continued to sponsor the annual PACAF Medical Conferences initiated by his predecessor, Major General O. K. Niess, now Surgeon General, USAF. These conferences are attended by medical representatives from all friendly Asian countries. They give each doctor an opportunity to share technical skills, scientific achievements and ideas. And they promote the Air Force Surgeon General's concept, "Peace through Medicine."

In recognition of his efforts in promoting harmonious relations with the peoples of the Far East and Asia, General Bohannon has been honored by several countries. He was the first foreigner to be elected to honorary membership in the Military Surgeons of Thailand, has been awarded the Chinese Air Force wings, and was cited by the Japanese Air Self-Defense Force.

During World War II, Dr. Bohannon served first in France and later in Germany with the headquarters, Ninth Air Force. In 1953 he became Surgeon for the Fifteenth Air Force, U. S. Strategic Air Command. He is a rated Chief Flight Surgeon.

A member of the Aerospace Medical Association, the Civil Aviation Medical Association, the American Medical Association, and the Industrial Medical Association, Doctor Bohannon is certified as a specialist in Aviation Medicine by the American Board of Preventive Medicine of which he is a Diplomate.

## General Cullen Relieves General Twitchell as Surgeon of USAFE

Maj. Gen. Cullen, the present Deputy Surgeon General, will succeed Maj. Gen. Harold H. Twitchell as Command Surgeon of the United States Air Forces in Europe at Wiesbaden, Germany. From 1950 to 1954, General Cullen served as Deputy Director of Plans and Hospitalization, Office of the Surgeon General, and two years later he was recalled to this position from his post as Commander of the USAF Hospital at Wimpole Park, England. Prior to his duty as Deputy Surgeon General, General Cullen served as Director of Plans and Hospitalization



GENERAL CULLEN

in the Office of the Surgeon General, in which position his responsibilities included all phases of planning to support the military mission in peace and war, management and operation of the worldwide Air Force hospital system, medical logistical support and Air Force Biometrics. General Cullen is rated as Senior Flight Surgeon

and is board certified in aviation medicine. He is a Diplomate of the American Board of Preventive Medicine (Aviation Medicine) and a Fellow of the American College of Preventive Medicine.

## General Twitchell Retires

Major General Harold H. Twitchell, now serving as Command Surgeon of the United States Air Forces in Europe, will retire in June and will be associated with the Department of Health and Hospitals, Denver, Colorado. A veteran of thirty-two years of active service, General Twitchell's more recent assignments have included duty as Chief of the Armed Forces Medical Council's Planning Coordination Division in the Office of the Secretary of Defense; Director of Plans and Hospitalization and Director of Professional Services, Office of the Air Force Surgeon General; and Surgeon of the Continental Air Command. During World War II he served as Surgeon of the Second Air Force, the Twenty-First



GENERAL TWITCHELL

## AEROSPACE MEDICAL NEWS

Bomber Command, and the Twentieth Air Force in the Pacific Theatre, where he had the responsibility of establishing medical care for Air Force personnel in advance echelons. A recent past President of the Association of Military Surgeons, General Twitchell is rated as Chief Flight Surgeon and is certified as a Diplomate of the American Board of Preventive Medicine. He is also a member of the American College of Surgeons, the American Medical Association, and the Aerospace Medical Association.

### Retirement of General Brownton

Another Air Force general officer retires this month as Brigadier General Sheldon S. Brownton terminates a career of twenty years of active duty. After duty



GENERAL BROWNTON

as Surgeon of the First Air Force and the Continental Air Command, General Brownton served as staff member, executive assistant and Director of the Staff of the Armed Forces Medical Policy Council in the Office of the Assistant Secretary of Defense. He has also been closely associated with the medical departments of other federal agencies, has

participated in the medical plans and activities of the NATO Medical Conferences at SHAPE Headquarters in Paris, and as Military Medical Advisor for the Department of Defense attended the meeting of the World Health Organization in Geneva in 1954. Rated a Senior Flight Surgeon and certified in Aviation Medicine as a Diplomate of the American Board of Preventive Medicine, General Brownton is a Fellow of the Aerospace Medical Association. He has become Chief Medical Officer of the New York Worlds Fair.

### International Academy of Astronautics Elects New Members

The International Academy of Astronautics has recently elected thirty new members to the Basic Sciences, Engineering Sciences and Life Sciences Sections, and named Niels Bohr as its first honorary member. The eleven additions to the Life Sciences Section were: Dr. Robert Grandpierre, Director, Aviation Medicine Research Center (France); Prof. U. S. von Euler, Department of Physiology, Karolinska Institute (Sweden); Dr. Ashton Graybiel, Director of Research, U. S. Naval School of Aviation Medicine (U.S.A.); Prof. Thomaso Lomonaco, Director, Research Center

for Aviation Medicine (Italy); Prof. Rodolfo Margaria, former Director, Research Center for Aviation Medicine (Italy); Dr. Hermann J. Schaefer, Research Department, U. S. Naval School of Aviation Medicine (U.S.A.); Prof. Gustav Schubert, Physiological Institute, University of Vienna (Austria); Col. John P. Stapp, Aerospace Medical Center, Brooks A.F. Base (U.S.A.); Air Com. W. K. Stewart, R.A.F. Institute of Aviation Medicine, Farnborough (Great Britain); Dr. P. M. Van Wulften Palthe, National Aeromedical Center (Netherlands); and Sir Harold E. Whittingham, a Chief Medical Officer, B.O.A.C. (Great Britain). The members of the Life Sciences Section previously appointed by Dr. Theodore von Karman, Director of the Academy, were Dr. W. Randolph Lovelace II (U.S.A.), Brig. Gen. Don Flickinger (U.S.A.), and Col. Edgar Evrard (Belgium). The Academy now has a membership of seventy-six, coming from eighteen countries.

Created by the International Astronautical Federation at Stockholm in August, 1960, for the purpose of promoting the advancement of astronautical sciences, the Academy is financed by a grant from the Daniel and Florence Guggenheim Foundation. A report on the founding of the Academy is carried on page 770, volume 31, of the Journal. Its next meeting will be held in Washington in October, 1961, in conjunction with the annual congress of the Federation, at which time the first Daniel and Florence Guggenheim International Astronautics Award will be presented.

### IAF Ad Hoc Committee

During the XI Congress of the International Astronautical Federation held in Stockholm in August, 1960, an ad hoc committee was formed: (1) to study present radiological safety criteria for astronautics and (2) to investigate and report upon established channels for the interchange of information in space medicine and biology. The committee is composed of Professor Carl-Johan Clemenson, Chairman (Sweden); Prof. Hubertus Strughold (U.S.A.); Dr. A. Cabanon (France); Brig. Gen. Don D. Flickinger (U.S.A.); Col. Carl Houghton (U.S.A.); Dr. E. M. Juganova (U.S.S.R.); Dr. L. Novak (Czechoslovakia); Dr. Zbigniew Packowski (Poland); Dr. L. R. Shepherd (England); and Dr. Eugene B. Konnecci (U.S.A.).

The first function was included after a proposal made by Dr. Wright Langham, Los Alamos Scientific Laboratory (U.S.A.), in his paper on "Some Radiation Problems of Space Conquest." To accomplish the second point the committee has decided to consult the national astronautical societies and also some international space research organizations as to the best ways to exchange scientific information within space biomedical and behavioral science fields. Opinions have been requested from the Aerospace Medical Association.

## Doctor Kidera Receives President's Award



Dr. George J. Kidera, medical director of United Air Lines, recently received the President's Award for 1960, given annually by United to an outstanding employee. Presented by W. A. Patterson, United's President, the plaque commemorating this honor bears the inscription "Presented to G. J. Kidera, M.D., as the highest honor for distinguished service to his company."

Doctor Kidera was chosen for the award in recognition of "long-time service by him and his staff to the well-being of United's flight personnel and other employees of the company." He was also honored for "his valuable research and assistance in solving physiological problems relating to air transportation." Doctor Kidera has directed United's medical department since 1951. The department has a staff of 39 and five regional offices, as well as a clinical research unit at San Francisco which is investigating and developing techniques for early diagnosis of heart disease and conducting studies in musculo-skeletal infirmities.

## FAA Issues Restatement of Certification Procedures

The Federal Aviation Agency's restatement of Part 406 certification procedures, which was published in the Federal Register in December, has recently been re-issued by the Government Printing Office in pamphlet form and may be obtained from that office for five cents. This revision incorporates outstanding

amendments, up-dates terminology and deletes obsolete material.

Subpart B of Part 406, which contains the sections dealing with medical certification, includes the procedural regulations governing the issuance of first, second, and third class medical certificates. Also set forth are the regulations delegating the authority of the Administrator to issue or deny medical certificates to the Civil Air Surgeon and his authorized representatives; providing that denial of a medical certificate by

an aviation medical examiner shall be subject to reconsideration by the Civil Air Surgeon or his authorized representative; providing for reconsideration of a denial by the Civil Air Surgeon of a medical certificate by petition to the Administrator; and providing for medical certification by senior flight surgeons of the military services.

Subpart C of Part 406 deals with the availability of medical history and provides that if the Administrator or his authorized representative finds that additional medical history is necessary to determine whether an applicant for or a holder of a medical certificate meets the physical standards therefor, such applicant or holder will be requested to authorize the release to the Administrator or his authorized representative any available records or information concerning such medical history.

### Doctor Benford Donates Personal Aviation Medical Library to Harvard

Dr. Robert J. Benford, former editor of the *Aerospace Medicine* and the *U. S. Armed Forces Medical Journal*, has recently presented the Harvard Medical Library with his personal collection of some 2,000 books, pamphlets, journals and booklets concerned with aviation and space medicine and related topics. The library serves the Harvard Medical School, the Harvard School of Public Health and the Harvard School of Dental Medicine.

Announcement of Doctor Benford's gift was made on March 15 at a dinner meeting on the opening day of the medical seminar for aviation medical examiners by Dr. Ross A. McFarland, seminar chairman. Mr. Ralph Esterquest, Librarian of the Harvard Medical School, School of Public Health and Dental School, described Doctor Benford's collection as "an outstanding collection of works in aviation and space medicine and related subjects." He went on to say that it would form the nucleus of a collection in this new and rapidly developing field, one in which the Library of Medicine would specialize in the future.

### Harvard and Tulane FAA Seminars

The Bureau of Aviation Medicine of the Federal Aviation Agency, in conjunction with medical schools throughout the country, is conducting medical seminars for the aviation medical examiners. These seminars cover the fields of cardiology, ophthalmology, otorhinolaryngology, physiology, neurology, pathology, psychology, use of drugs, as well as other associated subjects dealt with by the aviation medical examiner.

The Bureau plans to conduct twenty-four such seminars each year over the country. The two semi-

### Life Sciences Committee Report

The Life Sciences Committee Report, titled *Present Activity in the Life Sciences*, is now available and may be obtained on request from the Aerospace Medical Association, Washington National Airport, Washington 1, D. C. This report covers twenty-five areas in the life sciences, gives the facilities doing work in those problem areas, and lists the person to contact at each facility. Among the categories covered are such problem areas as Human Limitations to Cold, Weightlessness, Human Metabolic and Energy Requirements in Space, Methods of Providing for Human Needs in Prolonged Space Flights, Communication with Space Crews, and Effects of Multiple Stressors.

nars presented in March were in conjunction with the Guggenheim Center for Aviation Health and Safety, Harvard School of Public Health, and the Harvard Medical School in Boston, Massachusetts; and Tulane University School of Medicine in New Orleans, Louisiana. Both programs were rated as outstanding by all those in attendance.

The seminar in Boston was chaired by Dr. Ross A. McFarland, Director, Guggenheim Center for Aviation Health and Safety, with presentations by members of the Harvard School of Public Health faculty, Harvard Medical School faculty, staff members at Peter Bent Brigham Hospital, Massachusetts General Hospital, Massachusetts Eye and Ear Infirmary, personnel from the Federal Aviation Agency and the Civil Aeronautics Board, and listed the main guest speaker as Dr. Paul Dudley White, who discussed "Maintaining Fitness in Airmen." Among other topics under consideration during the three-day meeting were the effects of oxygen lack, diagnostic techniques for diabetes, the effect of drugs on flying personnel, general physical fitness standards, use of electrocardiograms, problems of aging in pilots, the diagnosis and control of ulcers, eyesight and hearing tests, the medical aspects of accident investigation, and problems related to air traffic control.

The seminar at Tulane University School of Medicine was chaired jointly by Dr. C. G. Grulee, Jr., Associate Dean and Director of Graduate Medicine, and Dr. Paul Pratho, Regional Flight Surgeon, Region II, Federal Aviation Agency. Presentations were made by faculty members of Tulane University School of Medicine, personnel from Brooks Air Force Base, Texas, personnel from the Federal Aviation Agency and the Civil Aeronautics Board, faculty members at the University of Texas, Southwestern Medical School, Dallas, Texas. Guest speaker was Dr. Stanley R. Mohler, National Institute of Health, Washington, D. C.

## News of Members

**Lt. Charles E. Hartford, USN**, formerly at the Naval School of Aviation Medicine at Pensacola, has been reassigned as flight surgeon, VX-6 Squadron, Quonset Point, R. I.

**Lt. Raymond F. Austin, Jr., USNR**, has also left the Naval School of Aviation Medicine at Pensacola and is now serving with the Commander Carrier Anti-Submarine Air Group 54, F.P.O., New York, N. Y.

**Col. John F. Dominick, USAF (Ret.)**, is now Medical Director of the Lakeland General Hospital, Lakeland, Florida.

**Harald J. von Beckh, M.D.**, Technical Advisor, USAF Aeromedical Field Laboratory, Holloman AFB, New Mexico, has been awarded honorary membership in the Medical Association of the Armed Forces of the Argentine Republic.

**Col. Carl J. Schopfer**, State Surgeon of New Jersey, Reserve Officers Association, announces the formation of a New Jersey Chapter of the Association of Military Surgeons of the United States. Members interested in this new chapter are urged to contact Col. Schopfer at 57 Park Place, Bloomfield, N. J.

**Col. R. Howard Lackay, USAF**, has been named Deputy Commander, USAF Aerospace Medical Center, where he has been serving as Director of Medical Operations. Before coming to the Center, Col. Lackey, who has more than twenty years of active service, was Director, Base Medical Services, 86th Tactical Hospital, Ramstein AFB, Germany.

**Douglas R. Collins, Jr., M.D.**, has moved from Sepulveda, Calif., to Van Nuys, Calif.

**Capt. Richard S. Colvin, USA**, has returned from overseas duty to Martin Army Hospital, Fort Benning, Georgia.

**Col. N. Robert Drummond, USAF**, has been reassigned within the Continental Air Command from its headquarters at Mitchell AFB, N. Y., to Hq. CONAC (SPS), Robins AFB, Georgia.

**Capt. Raymond F. Cole, USAF**, has returned from overseas duty and been assigned to the 801st Medical Group, Lockbourne AFB, Ohio.

**Lt. Larry R. Fout, USNR**, has been assigned to overseas duty from the Naval School of Aviation Medicine, Pensacola, Florida.

**Capt. Clifford L. Mayhew, USAF**, has left the School of Hygiene and Public Health at Johns Hopkins University for duty at the USAF School of Aviation Medicine, Brooks AFB, Texas.

**Maj. George K. Reberdy, USAF**, formerly at Hq. 29th Air Div. (SAGE), Malstrom AFB, Montana, has been assigned to the USAF Hospital, Wiesbaden, Germany.

**Theodore E. Patrick, M.D.**, of Picture Rock, Pa., is now with the Department of State (Washington 25, D. C.) in the Foreign Service Reserve and serving in Mogadisco.

**Capt. Don J. Rosato, USA**, has been reassigned from Devon, Pa., to Camp Wolters, Mineral Wells, Texas.

**James S. Gage**, formerly at the Hawthorne School of Aeronautics, Moultrie, Ga., is now in Tallahassee, Fla.

**Robert W. Gustafson, M.D.**, has moved from Fairmont, Minn., to Spring Valley, Minn.

**Robert William Hamilton, Jr.**, formerly of Coon Rapids, Minn., is now in Minneapolis, Minn.

**Bernhard J. F. Kramer, M.D.**, formerly a major, USA, stationed at Walter Reed General Hospital in Washington, is now living in Silver Spring, Md.

**Rodney Ian MacDonald, M.D.**, has been reassigned from the U. S. Naval Hospital at El Toro, Calif., to overseas duty with the 1st Marine Aircraft Wing, FPO, San Francisco.

**Seymour N. Stein, M.D.**, has been reassigned from the Naval Medical Research Institute, Bethesda, Md., to the Pacific Missile Range, Point Mugu, Cal.

**Cole Stephens, M.D.**, formerly a captain, USAF, has left Salem, Ore., and is now with the Presbyterian Medical Center, San Francisco, Calif.

**Capt. John W. Funk, USAF**, has been reassigned from the 14th USAF Dispensary, Ethan Allen AFB, Vermont, to the 337th Hospital, Portland, Ore.

**Capt. Lawrence W. Weber, USAF**, formerly in the Aviation Medicine Division, Office of the Surgeon General, Washington, is now on overseas duty with the 7112th Central Medical Group, APO 332, N. Y.

**Charles E. Cook, M.D.**, has moved from Muskogee, Okla., to Bonham, Texas.

**Lt. John P. Skelly, USNR**, has been reassigned from the Naval School of Aviation Medicine, Pensacola, Fla., to the 3rd Marine Air Wing, El Toro, Calif.

## New Members

ARNOLD ALBERT, M.D., San Antonio, Texas

NEWTON W. ALLEBACH, Commander, USN

FRIEDRICH AUSBUETTEL, Lt. Col., German AF

LOUIS P. BALLEMBERGER, Captain, USN

ALPHONSO A. BELSITO, Lt., USNR

ROBERT A. BUCHANAN, M.D., Detroit, Mich.

JOHN T. BURCH, M.D., San Pedro, Calif.

ALVIN M. BURNER, Major, USAF

## LETTER TO THE EDITOR

HARRY BURNS, M.D., Des Moines, Iowa  
HANS-GEORG CLAMANN, M.D., Brooks AFB, Texas  
ROBERT H. COFIELD, M.D., Fort Thomas, Ky.  
JAMES R. CRISCIONE, M.D., St. Louis, Mo.  
PAUL B. CROWLEY, M.B., Australia  
HENRY M. CRYER, JR., M.D., Albuquerque, N. M.  
RICHARD S. DAVIDSON, PH.D., Columbus, Ohio  
CEBBAR DENGIZ, Captain, Turkish AF  
GARTH B. DETTINGER, Major, USAF  
BERNARD C. DOYLE, Washinton, D. C.  
BENJ. H. ERSHOFF, PH.D., Culver City, Calif.  
ROBERT A. FARMER, Captain, USAF  
WOODARD E. FARMER, M.D., Asheville, N. C.  
RICHARD FEINBERG, PH.D., Washington, D. C.  
ADJO A. FREEMAN, M.D., Los Angeles, Calif.  
I. M. FRENCH, M.D., Wahoo, Nebraska  
HORACE R. FRIERSON, M.D., El Segundo, Calif.  
ZENICHIRO FUJIE, Major, Japan ASDF  
JOSEPH B. GILLERMAN, Los Angeles, Calif.  
WALTER J. GRANT, M.D., American Lake, Wash.  
SAMUEL M. HANAUER, M.D., Galesburg, Ill.  
PETER G. HANSON, Lt., USAF  
HAROLD R. HUNT, Lt., USN  
ROBERT H. HUTCHINSON, M.D., Long Beach, Calif.  
JIMMIE H. JOHNSON, Lt. (jg), USN  
HENRY J. KLAUNBERG, PH.D., Coral Gables, Fl.  
TIMOTHY A. LAMPHIER, M.D., Boston, Mass.  
DAVID P. LARSON, Captain, USAF  
WILLIAM L. LEE, JR., Captain, USAF  
ROBERT E. LESLIE, M.D., El Campo, Texas  
PHOCIAN WARD MALONE, M.D., Big Spring, Texas  
SAMUEL MARKARIAN, Lt., USN  
JOSEPH C. MEEK, JR., Lt., USN  
GEORGE C. MOHR, Captain, USAF  
WILLIAM C. NOWLIN, M.D., Littlefield, Texas  
ZEYYAT ONAT, Lt. Col., Turkish AF  
NORMAN PANTING, M.D., Santa Rosa, Calif.  
IRVING B. PERLSTEIN, M.D., Louisville, Ky.  
DUANE F. PILE, M.D., Crosby, N. D.  
ALLEN EUGENE PRIEST, M.D., Fair Oaks, Calif.  
STEPHEN A. PYE, Lt., USN  
ARTHUR PHILLIP RAUN, 1st Lt., USAF  
SAMUEL C. REXFORD-WELCH, W/C, RAF  
W. C. ROUNTREE, Lt. Colonel, USAF  
GUENTHER A. SCHIRRMANN, Major, German AF  
VICTOR SCHOCKEN, M.D., Flushing, N. Y.  
JAMES B. SCHOFIELD, JR., Captain, USAF  
WILLARD G. SENG, M.D., Oshkosh, Neb.  
WILLIAM A. SIBRANS, M.D., Flushing, N. Y.  
JOHN T. SMALL, M.D., Barstow, Calif.  
SIDNEY SMITH, M.D., Bradenton, Fla.  
DANIEL F. STOUGH, M.D., Geary, Okla.  
R. W. THOMAS, M.D., Redding, Calif.  
JOSEPH F. TOMASHEFSKI, M.D., Columbus, Ohio  
CLARENCE W. TREXLER, M.D., Honolulu, Hawaii  
VICTOR Y. TYRONE, JR., Captain, USAF  
DAN L. URSCHEL, M.D., Mentone, Indiana  
LLOYD A. WHITESSELL, M.D., Minneapolis, Minn.  
ROBERT A. WINSTANLEY, M.D., Johnstown, Pa.  
LEROY A. WOLEVER, M.D., Drumright, Okla.  
RICHARD LYNN WOLF, Palmdale, Calif.  
WALTER ZURNDORFER, M.D., Chicago, Ill.

MAY, 1961

## Letter to the Editor

Dear Editor:

In the March 1961 issue of *AEROSPACE MEDICINE*, beginning on page 197, is an article by Karl E. Schaefer, entitled "A Concept of Triple Tolerance Limits Based on Chronic Carbon Dioxide Toxicity Studies." On page 203 of this article, he says:

"For example, Bartlett<sup>1</sup> made the apparently serious suggestion to use carbon dioxide-rich atmospheres in confined spaces since man, after all, is accustomed to a high carbon dioxide level of 5.5 per cent in the alveolar air and shows a great tolerance to carbon dioxide under conditions of embryonic life. This statement was for obvious reasons based on a misunderstanding of the significance of carbon dioxide gradients between organism and environment, and unawareness of the established effects of chronic carbon dioxide exposure. It emphasized, however, the pressing need for a framework of tolerance limits."

The paper by R. G. Bartlett, to which Dr. Schaefer referred, appeared in *Proc. Symp. Closed Circuit Resp. Systems*, April 1960. WADD Tech. Rep. 60-574. The following quotations are from the last two paragraphs of this paper:

"Answers to these questions relative to possible effects of a nitrogen-free and/or CO<sub>2</sub> rich atmosphere are needed to guide in construction of the space cabin and regulation of its atmosphere. When considering changes of the atmosphere, it is perhaps well to remember the statement attributed to Joseph Priestly, 'Our atmosphere is as good as we deserve,' or its corollary, we may be what we are because of what our atmosphere is and if we change our atmosphere from what it is we must make sure that the new atmosphere in turn does not change us from what we are.

"Although the above presentation might suggest a feeling that departures from our normal atmosphere, i.e., removing the nitrogen and somewhat elevating the carbon dioxide are compatible with normal functional integrity, it should be stressed that there is no thought that the atmosphere should be altered without substantial experimentation, indicating that such alterations are neither acutely nor chronically disadvantageous."

Neither in the talk nor in the printed paper was there any mention of CO<sub>2</sub> levels during intrauterine life.

R. G. BARTLETT, JR.

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## Book Reviews

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**MAN IN SPACE.** Edited by Kenneth F. Gantz. Duell, Sloan and Pearce, New York, New York, 1959. 303 pages, \$4.00.

A great deal has been written about the equipment, machines, and vehicles being designed to conquer space, but all too little has been said about the complex factors involved in the forthcoming travels of man in space. Foremost in the research and development of the ways and means needed to launch man on successful space flights is the United States Air Force.

This book presents a survey of key findings, problems, factors, conditions involved in man's space travel. The development of astrobiology and the basic factors in manned space operations, the biodynamics of manned space flight, and observations on the biological hazards of radiation in high-altitude flights are considered in detail.

The biomedical aspects of space flight, problems of weightlessness, the space travel environment, the military impact of space operations, the engineering of the space vehicle environment, and problems of general human engineering are all topics of detailed discussion by leading authorities in each field.

**MODERN NUCLEAR TECHNOLOGY.** Edited by Mark M. Mills, Arthur T. Biehl and Robert Mainhardt. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York, 1960. 336 pages, \$9.50.

The material contained in this book is, for the most part, the result of a series of lectures given as a survey course at the University of California in Berkeley. The purpose of the survey course was to present on a management level the fundamentals of nuclear engineering, in order to help management personnel understand some of its problems. The level of presentation was directed toward the mature industrialists who had an engineering degree but had not been actively engaged in engineering for five to ten years, or who was part of management and had sufficient experience in the administration of engineering progress. Therefore, no lectures were given on basic engineering principles or methods of approach for the solution of engineering problems. Accordingly, many of the lectures are rather unsophisticated for the nuclear expert or the engineer actively engaged in reactor design or operation.

Each chapter stands by itself, since it corresponds to a lecture given by an individual. Little effort has

been made by the Editors to cross-correlate data between chapters.

Much emphasis is placed on the "new Nuclear engineering vocabulary." As practiced today, nuclear engineering uses a confusing set of units and introduces some new words. Historically, the units have been developed by the physicists; therefore, the metric system is commonly used; while the older field of heat transfer maintains the more familiar English units. A glossary of the new vocabulary of nuclear engineering is included, and every effort is made throughout the book to use the words in their proper context so that the non-expert may learn how to use them.

This book is of much value as a reference book to those presently involved with or who will become involved with all aspects of the applications of nuclear energy.

**ADVANCES IN SPACE SCIENCE, VOLUME 2.** Edited by Frederick I. Ordway, III. Academic Press, Inc., 111 Fifth Avenue, New York 3, New York, 1960. 450 pages, \$13.00.

Five major areas are covered in the six chapters that comprise this book. These include space physics, tracking, materials, electrical propulsion systems, and attitude control. While these subjects are obviously critical to the orderly development of space science and technology, they have not heretofore received comprehensive treatment in the permanent literature. It is, therefore, to be expected that the reviews and analyses of these topics, prepared by widely recognized authorities, will be welcomed by the astronautical community.

During 1959 and 1960, expanding attention was placed on sending instrumented probing vehicles into the environment beyond the effective atmosphere of the earth, some being established in orbit around our planet, some being sent on missions toward, on, or around the moon, and still others being launched over trajectories that carried them deep into interplanetary space. Such vehicles have proven increasingly reliable and capable of undertaking an astonishing variety of physical and astronomical investigations. As man launches more payloads into space, the tracking problem becomes increasingly complex, explaining why concerted efforts are being focused on the establishment of national and international surveillance and deep space tracking networks. Techniques and instruments are discussed which have been devised to explore the nature of the earth's magnetic field;



## BOOK REVIEWS

interplanetary and planetary fields; radiations from the sun and space; lunar, planetary, and stellar features; interplanetary plasma; and micrometeorites. As satellites and spacecraft become more complex and are required to perform ever more precise investigations of geophysical and astrophysical phenomena, problems of attitude control become correspondingly acute. Recent developments in this field are discussed.

The material presented in this volume is concise and well written and will be of great interest as a ready source of reference material.

**ELECTROENCEPHALOGRAPHY IN ANESTHESIOLOGY.** By Albert Faulconer, Jr. and Reginald B. Bickford. Charles C Thomas, 301-327 East Lawrence Avenue, Springfield, Illinois, 1960. 90 pages, \$4.75.

The main body of this book is devoted to a review of the present status of the interpretation of brain waves during the administration of drugs used by the anesthesiologist. For each of the major agents a specimen classification of electroencephalographic changes during increasing doses is shown and described in detail.

Other important chapters in the book deal with the mechanism of electroencephalographic changes, the nature and characteristics of brain waves, physiologic aspects of changes induced by anesthesia, the electrophysiologic basis of the anesthetic state, practical aspects of instrumentation, operating-room use of various forms of apparatus available, principles and practice of servoanesthesia and specific applications and methods for electroencephalographic control of depth of anesthesia.

The book contains an extensive bibliography which will serve to guide the reader to more detailed discussions of every phase of the science.

This volume will be of great interest to the basic research investigator and to the specialist in anesthesiology.

**LOW-LEVEL IRRADIATION.** Edited by Austin M. Brues. American Association for the Advancement of Science, Publication No. 59, Washington, D. C., 1959. 158 pages, \$3.75.

This book contains the proceedings of a symposium on the radiation effects at low levels. In the first half consideration is given to the nature and amount of radiation to which man is normally exposed and that which he receives from various man-made sources including fallout. This is followed by discussions regarding meteorological conditions determining the geographical distribution of fallout and how fallout observations have clarified some problems in meteorology. The genetic and somatic effects of small amounts of radiation on man are considered, indicating the limits of our knowledge.

In the second half of the book, consideration is given to the responsibilities of public health authorities, the press, the legal and political implications and a summation in terms of the basic meaning and trends of scientific thought and organization.

This book is of considerable importance because the question of the consequences of exposure of human beings to low levels of ionizing radiation has attracted more general attention and given rise to more widespread public debate than any other question in which the scientific facts are so essential but so few. The profound underlying anxiety of all people about the influence of technological progress on the nature of any future global war has found itself a more emotionally tangible focus in the fallout hazard, which can be considered in a less personal, more statistical way.

It is evident that a considerable number of scientific authorities speaking on the subject of low-level irradiation have assumed also the role of political sages and that many of the divergent scientific evaluations are colored by convictions in the somewhat more taboo area of the threat of worldwide military destruction. The book points out that an unfortunate consequence of all this has been that a bewildered and insecure public, noting that such contrary opinions are held by scientists in possession of the same facts, feels that science has somehow failed. These matters and the implications thereof are discussed at length in the book.

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## New Books

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**ELECTRONICS AND NUCLEONICS DICTIONARY.** By Nelson M. Cooke and John Markus. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York, 1960. 543 pages, \$12.00.

**ATOMIC MEDICINE.** Edited by Charles F. Behrens, M.D., F.A.C.R. The Williams and Wilkins Company, Baltimore 2, Maryland, 1959. 705 pages, \$15.00.

**NUCLEIC ACID OUTLINES, VOLUME I.** By Van R. Potter. Burgess Publishing Company, 426 South Sixth Street, Minneapolis 15, Minnesota, 1960. 292 pages, \$5.00.

**GLOSSARY OF WORDS AND PHRASES IN RADIOLOGY AND NUCLEAR MEDICINE.** By Lewis E. Etter, B.S., M.D., F.A.C.R. Charles C Thomas, 301-327 East Lawrence Avenue, Springfield, Illinois, 1960. 203 pages, \$8.50.

**HUMAN FACTORS IN JET AND SPACE TRAVEL.** Edited by S. B. Sells, Ph.D. and Charles A. Berry, M.D. The Ronald Press Company, 15 East 26th Street, New York 10, New York, 1961. 386 pages, \$12.00.

# Federal Aviation Agency Bureau of Aviation Medicine

## Questions and Answers of Interest to Aviation Medical Examiners

*Q.—I am a recently appointed aviation medical examiner, but I have not as yet examined any applicants. How do applicants find out whom to see?*

A.—Any person desiring a student permit, private, or commercial certificate must contact the nearest Federal Aviation Agency General Aviation District Office for an application. The GADO maintains a current list of all aviation medical examiners in the area and this list is available to all applicants.

The FAA Air Carrier District Offices maintain a current list of the AMEs designated to give Class I medical examinations, and this list is also available to all pilots requiring or maintaining a Class I certificate. Medical Directors of airlines are furnished current lists of Class I examiners.

All flight training schools are furnished lists of AMEs in their vicinities. Most airport managers maintain a current list of all AMEs in their vicinities, as well as the FAA Flight Service Stations located throughout the country.

Complete lists of AMEs are furnished all State aviation directors.

*Q.—Why should applicants with controlled glaucoma (medical) be denied a Class III card? (My glaucoma patients lead normal lives, drive cars, et cetera.)*

A.—The big danger is that an individual may have a progressive loss of peripheral fields. A sudden acute rise of intraocular tension may seriously retard the function of the retina. This acute attack may arise within one hour. The likelihood of an acute exacerbation is reduced in those under adequate treatment but there have been cases which have gone into the acute phase for no apparent reason.

Persons with glaucoma usually have trouble adjusting from daylight to darkness. Even those under good control complain about having difficulty in darkness.

*Q.—Could not the color vision test be eliminated once a pilot has demonstrated his ability to pass the test? Does it ever change?*

A.—Deane B. Judd, in 1943, issued a report exploring "the belief that a man though red-green blind

from birth can still develop a red-green sense from certain drugs, diets, or other treatments . . . the lives of the whole crew of an aircraft (and passengers) may be the price to pay for the delusion of one crew member that his color vision is normal just because he took treatments and learned to pass a color vision test."

Men can be coached to pass the test but this does not repair the physiologic deficiency. A prominent eye specialist passed the color vision test in World War I, but was only 75% correct on the color vision test when examined for World War II. The illumination, amount of sleep, and the time of day have an effect upon this doctor so that he may pass one time and fail the next.

Furthermore, acquired color deficiency may occur. This may be brought about by effects of toxic agents such as alcohol or tobacco or by ill-fitting contact lenses.

*Q.—Why is it not permissible for an internist and an ophthalmologist to both examine and both sign the report as used to be done in the Army?*

A.—The responsibility for the report rests with the designated aviation medical examiner to whom the applicant went for examination. There can be no dualism of responsibility.

*Q.—What limitations may be initially placed on the medical certificate by the AME?*

A.—These are listed under Chapter III, page 5, item D of the *Guide for Aviation Medical Examiners*. All other cases should be referred to the Civil Air Surgeon.

*Q.—How long after performance of the medical examination should a copy of the letter of denial be forwarded to the FAA?*

A.—It should be forwarded the day of the examination.

## Aerospace Medicine

# Abstracts of Current Literature

Prepared under the Direction of ARNOLD J. JACOBUS, Ph.D.

For the reader's convenience, papers are classified by their principal contents into thirteen broad categories. Readers are advised to consult all related categories for full coverage of their field.

### History and General Aspects

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**Aviation Medicine.** H. V. ELLINGSON.—In: *Cyclopedia of medicine, surgery, and specialties: Review Service*, 1960, p. 221-246. Ed. by G. M. Piersol and E. L. Bortz. Philadelphia: F. A. Davis Company, 1960.

The scope and implications of aviation and space medicine are summarily discussed. Consideration is given to the general and specific stresses which may be encountered, to medical and psychiatric problems, air travel and transportation of patients, pilot and astronaut selection, protective equipment and clothing, and to flying safety and accidents involving nuclear weapons. (88 references)

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**Review of Achievements in Cosmic Medicine** (Przegląd osiągnięć medycyny kosmicznej). S. HADUCH and S. BARANSKI.—*Wojskowy przegląd lotniczy* (Warszawa), 8 (4):70-76. April 1960. In Polish.

This is a brief review of the papers read at the second World Congress of Aviation and Space Medicine, held in the Fall of 1959, in Rome, Italy.

From the Science and Technology Division, Library of Congress, Washington, D. C. Eugene Marrow, Ph.D., Editor of Abstracts. Dr. Jacobus is senior editor of *Aerospace Medicine: An Annotated Bibliography* (formerly *Aviation Medicine*). Volume II (1953 literature), published by the Aerospace Medical Association is available from Bruce Publishing Company, 2642 University Avenue, Saint Paul 14, Minnesota. Volumes I and III can be purchased from the Office of Technical Information, U. S. Department of Commerce, Washington 25, D. C.

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MAY, 1961

### Biology

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**Limitations on Space Flight Due to Cosmic Radiations.** H. J. CURTIS.—*Science* (Washington), 133 (3449):312-316. Feb. 3, 1961.

The differences in origin, physical characteristics, and biological aspects of cosmic rays and Van Allen radiation belts are discussed. From the known and postulated theories about these radiations, the following conclusions are reached: (1) flight below the Van Allen belts seems reasonably safe without radiation shielding; (2) it is probably impractical to shield a rocket sufficiently to permit a man to remain in the inner Van Allen belt for more than about an hour, but it should be possible for him to go through it without serious harm; (3) shielding for the outer Van Allen belt is possible but would have to be quite heavy if a stay of more than a few hours were contemplated; (4) the primary cosmic radiation is not intense enough to deliver a serious radiation dose, even for exposures of a few weeks, and the heavy cosmic ray primaries do not seem to present an unusual hazard. (Quoted in part)

304

**Exobiology — Experimental Approaches to Life Beyond the Earth.** J. LEDERBERG.—In: *Science in Space*, Chapt. IX, p. 4-19. Washington, D. C.: National Academy of Sciences—National Research Council, 1960.

Also published in: *Space Research*, p. 1153-1170. Ed. by H. K. Bijl. Amsterdam: North-Holland Publishing Co., 1960.

Also slightly condensed in: *Science* (Washington), 132 (3424):393-400. Aug. 12, 1960.

The detection of life beyond the earth is one of the most exciting challenges of space science. The problems of exobiology have important implications for the development of theoretical biology and the understanding of mechanism of the evolution of life, as well as for general philosophical conceptions of man's place in the universe. The critical techniques

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of actual exobiological experimentation are believed to be those of microbiology, since micro-organisms for several reasons have a most important place in our consideration of program policy and in the solution of basic biochemical problems. Among the most important of these is the role of nucleic acids and proteins in the functioning of any organisms that may have evolved on other sites. The rapid growth of micro-organisms, and the variety of their adaptations to different environments, dictate the most rigorous care to prevent the unwanted transfer of contaminants from one planet to another. (Author's abstract)

305

**Proceedings of Meeting on Problems and Techniques Associated With the Decontamination and Sterilization of Spacecraft, June 29, 1960, Washington, D. C.**—Ed. by J. Posner. 57 p. National Aeronautics and Space Administration. Office of Life Sciences Programs, Washington, D. C. NASA Technical Note no. D-771, January 1961. Unclassified

A meeting was held of representatives of agencies concerned with the development of space vehicles and those investigating decontamination and sterilization procedures. Recommendations resulting from the deliberations include: (1) a body of related information be accumulated, (2) standard operating procedures be established, (3) acceptable limits of contamination be determined, (4) NASA policy be clarified, (5) new sterilizing agents be developed, (6) compatibility studies be pursued, (7) sterile manufacture of parts be investigated, and (8) a working level group should be formed to implement recommendations and procedures. (NASA abstract)

Appended to this report (p. 43-56) is a reprint of a paper by C. R. Phillips and R. K. Hoffman (see item no. 160).

## Physiology (General)

306

**Effect of Nutrient Supplements During Work on Performance Capacity in Dogs.** D. R. YOUNG, N. S. SCHAFER and R. PRICE.—*Jour. Applied Physiol.*, 15 (6):1022-1026. Nov. 1960.

The maximum treadmill performance capacity of dogs was linearly increased to a limiting value by consumption of increasing quantities of water during running. Consumption of milk, vitamins, and phospholipids caused a significant reduction in work capacity, while glucose and protein had no apparent effect. Work capacity showed no consistent relation to changes in blood components or to physiologic responses during running.

307

**The Sensory Receptor Organ and Quantitative Mechanism of Human Temperature Control in Warm Environment.** T. H. BENZINGER.—

Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):32-41. Dec. 1960 (Part II).

In widely varied warm environments and at widely varied levels of activity, responses and stimuli of human physical heat regulation were measured by gradient calorimetry and by cranial observations of internal body temperature. The inadequacy of rectal measurements was demonstrated. By forced dissociation of cutaneous from internal temperatures, by gradient calorimetric recordings of sweating and peripheral blood flow, with simultaneous recordings of the temperature stimulus at or near the two thermoreceptor sites, skin and internal cranial, in hot, warm, comfortable or cold environments, at low (20) or high (70 cal./sec.) metabolic rates, proof was obtained that warm impulses from skin thermoreceptors do not participate in the central neural temperature regulation of man by sweating, and most likely not in such control by vasodilatation. The role of the anterior hypothalamic heat center as a terminal sensory organ with first neurons for these functions is discussed. (Author's abstract)

308

**Cutaneous Vasomotor Nerves to the Head and Trunk.** D. A. BLAIR, W. E. GLOVER and I. C. RODDIE.—

*Jour. Applied Physiol.*, 16 (1):119-122. Jan. 1961.

Simultaneous measurements of skin temperature of various skin areas of the body were made during indirect cooling and heating of the body. Cooling the body caused a much larger fall in the nose and finger temperature than in mouth temperature, indicating active vasoconstriction in these areas. In the ear, cheek, chest and forehead there was no evidence of vasoconstriction. Evidence of vasodilatation in all the skin areas studied was obtained when the body was indirectly heated. Blocking the vasomotor nerves to the ear resulted in a large increase in skin temperature and, during body heating, the skin temperature of the normal ear did not exceed that of the nerve-blocked ear. It was concluded that the changes in ear blood flow subserving temperature regulation are mainly due to alterations in vasoconstrictor tone. In the chest and cheek, cutaneous nerve block did not alter skin temperature, yet it reduced the rise in skin temperature normally seen during body heating. It was concluded that the vasodilatation normally seen in these areas is not due to release of vasoconstrictor tone, but rather to an active vasodilator mechanism, mediated through fibers running with the cutaneous nerves. (Authors' abstract)

309

**Hypothermia for the Neurosurgical Patient.**

A. BOBA.—vii+124 p. Springfield, Illinois: Charles C Thomas, 1960.

The general concepts, the practical applications, and the technical details of inducing hypothermia are discussed in three chapters. The first chapter deals with the mechanisms of cooling and of heat transfer from the core to the shell of the body. Consideration is given to the effects of hypothermia upon (1) the general metabolism, (2) the cardiovascular system (heart rate, blood pressure, cardiac output, electrocardiogram, and myocardial dynamics), (3) the respiratory system (ventilatory mechanics and oxygen transfer), and (4) the central nervous system (brain volume, cerebrospinal fluid pressure, venous pressure, and inflammatory and reparative response patterns to standard injuries). With these general concepts as guides, the second chapter presents a practical basis for inducing hypothermia and gives consideration to the following: the effect of anesthetic agents on the mechanism of cooling; the importance of the interrelationship of body mass, cardiac output, and skin circulation on the determination of rate and depth of body temperature changes; the predictability of body temperature changes and the degree of reproducibility; the detection of shivering; the detection of metabolic or respiratory acidosis and fluid imbalance; and the hazards of hypothermia. In the third chapter, a hypothetical case of hypothermia is followed from preliminary preparations to the rewarming and recovery stage.

310

**Physiological Reactions of Men and Women During Muscular Activity and Recovery in Various Environments.** L. BROUHA, P. E. SMITH, R. DELANNE and M. E. MAXFIELD.—*Jour. Applied Physiol.*, 16 (1):133-140. Jan. 1961.

Men and women performing a standard exercise were studied in three environments. Pulmonary ventilation,  $O_2$  consumption,  $CO_2$  elimination, heart rate, blood pressure, body temperature and weight loss were recorded. Pulmonary ventilation was decreased in the warm-dry environment and increased in the warm-humid. Oxygen consumption was significantly lower in the warm-dry environment than at room temperature. The pattern of changes of these two functions was similar for both sexes. Respiratory exchange ratios were not influenced by sex, but were higher in the warm-dry environment. Increase in body temperature was found only in the warm-humid environment, with a smaller weight loss than in warm-dry conditions. Systolic blood pressure was influenced by work load but not by environments. Diastolic pressure varied little for both sexes under all conditions. Heart rate was significantly influenced by sex and environment, being highest for the women in the warm-humid conditions. Cardiac

cost increased and cardiac efficiency decreased in both warm surroundings, more so for women than for men. (Authors' abstract)

311

**Role of Thyroid Secretion in Cold Acclimation.** W. H. COTTLE.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):59-63. Dec. 1960 (Part II).

Experimental studies designed to evaluate thyroid secretion rate and its control during cold acclimation in small animals are reviewed. The possible role of the hormone in the process of acclimation is discussed. The suggestion that the increased resting metabolism of cold-acclimated animals is a product of the augmented thyroid secretion in the cold is untenable. Evidence is presented against the possibility that augmented thyroid secretion is prerequisite to development of the altered thermogenesis characteristic of cold acclimation. (Author's abstract)

312

**Adenohypophyseal Function in the Guinea Pig at Low Environmental Temperature.** S. A. D'ANGELO.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):51-56. Dec. 1960 (Part II).

The functional status of the pituitary-thyroid and adrenal systems was assessed in guinea pigs and rats maintained at moderately low temperatures ( $4-9^\circ C.$ ) for 1-10 weeks by measurement of BMR, serum protein-bound iodine, thyroidal  $I^{131}$  release rate, TSH content of blood and hypophysis,  $S^{35}$ -methionine tissue uptake, corticoid excretion, adrenal ascorbic acid, and pituitary ACTH, and by evaluation of gland morphology. The relationship of target gland functions to neural mechanisms was studied in cold-exposed animals after electrocautery of the hypothalamus. The results underscore the crucial role of the adenohypophysis in cold acclimation of the rodent. (Author's abstract)

313

**Body Glucose as Fuel for Thermogenesis in the White Rat Exposed to Cold.** F. DEPOCAS and R. MASIRONI.—*Amer. Jour. Physiol.*, 199 (6): 1051-1055. Dec. 1960.

Various parameters of glucose metabolism were measured with  $C^{14}$ -glucose in unanesthetized warm- and cold-acclimated rats at  $30^\circ$  and  $6^\circ C.$  Exposure of warm-acclimated rats to cold was associated with a decrease in turnover time of plasma glucose, no change in glucose pool size and space, an increase in rates of turnover and oxidation rate to the turn-

over rate, no change in percentage of respiratory  $\text{CO}_2$  derived from glucose oxidation, and a decrease in liver glycogen content. Approximately reversed changes were observed in cold-acclimated rats transferred from a cold to a warm environment except in the values of turnover time of plasma glucose and terminal liver glycogen content which underwent smaller changes. It is concluded that cold-induced thermogenesis in white rats, whether acclimated to warm or cold environments, is associated with an increase in carbohydrate catabolism proportionate to the increase in energy metabolism. (Authors' abstract)

314

**Calorigenesis From Various Organ Systems in the Whole Animal.** F. DEPOCAS.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):19-24. Dec. 1960 (Part II).

The capability of cold-acclimated rats to produce heat by means other than shivering is now well demonstrated. There is, however, disagreement on the site of origin of this thermogenesis. Recent work on the ability of functionally eviscerated, cold-acclimated rats to increase their oxygen consumption on exposure to cold points to extra-abdominal tissues as possible sites for nonshivering thermogenesis. Data on the ability of functionally eviscerated, cold-acclimated rats, as well as sham-operated cold-acclimated rats, to respond to noradrenaline bring additional evidence for the importance of extrahepatic tissues as the site of nonshivering thermogenesis. (Author's abstract)

315

**Glucose Metabolism in Warm- and Cold-Acclimated Rats.** F. DEPOCAS.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):106-109. Dec. 1960 (Part II).

Alterations in carbohydrate metabolism observed in warm- and cold-acclimated animals are reviewed, and recent work on the dynamics of glucose metabolism in warm- and cold-acclimated white rats exposed to warm and cold environments is described. (Author's abstract)

316

**Respiratory Consequences of Passive Body Movements.** M. E. DIXON, P. B. STEWART, F. C. MILLS, C. J. VARVIS and D. V. BATES.—*Jour. Applied Physiol.*, 16 (1):30-34. Jan. 1961.

The respiratory consequences of a number of passive body movements have been investigated in a group of normal subjects. It has been shown that certain types of torso movement produce hyperventila-

tion in excess of metabolic demand, with a consequent lowering of end-tidal  $\text{CO}_2$  tension. Passive pedal motion of the legs did not produce this type of hyperventilation and concealed it if performed in conjunction with the other movements. The mechanism for the passive hyperventilation is not understood, since the respiratory rate did not appear to be rhythmically linked to the body movement, and certain maneuvers in the experiments did not affect the results. The level of hyperventilation that has been demonstrated is considered to be adequate to explain the phenomenon of hyperventilation which has been recorded in pilots flying high-velocity low-level aircraft, who may be subjected to considerable jolting while sitting in an upright position. (Authors' abstract)

317

**Some Effects of Breathing Oxygen Before and After Exercise.** E. R. ELBEL, D. ORMOND and D. CLOSE.—*Jour. Applied Physiol.*, 16 (1):48-52. Jan. 1961.

Athletes in better than average physical condition breathed 100%  $\text{O}_2$  during 6 minutes of rest, air during 5 minutes of treadmill running at 8 m.p.h. and  $\text{O}_2$  during 19 minutes of recovery. The results were compared with a control procedure in which the same subjects breathed air throughout. It was found that the experimental procedure: (a) did not significantly facilitate recovery as based upon payment of  $\text{O}_2$  debt, measured by a closed-circuit spirometric method; (b) depressed the pulse rate during the first 2 minutes of exercise and during the recovery period; (c) caused the respiratory rate to increase at rest, to decrease during the initial part of the recovery period, and to increase during the latter part of the recovery period; (d) increased the percentage of  $\text{O}_2$  saturation of blood hemoglobin, as measured by an ear oximeter, during rest and recovery. Lower oximeter readings were found during the latter part of the exercise period. (Authors' abstract)

318

**Radiotelemetry of Physiological Responses in the Laboratory Animal.** S. J. M. ENGLAND and B. PASAMANICK.—*Science* (Washington), 133 (3446):106-107. Jan. 13, 1961.

A radiotelemetric system has been developed for use as an adjunct to studies in the classical conditioning of animals. The system will permit the monitoring and recording of selected physiological reactions in intact, unanesthetized laboratory animals during their normal daily routines in a simulated normal environment uncontaminated by the intervention of the experimenter and experimental procedures, except for planned changes in the controlled environmental chambers. Permanently-implanted, transistorized, miniaturized, battery-powered packages permit short-dis-

tance propagation of selected physiological activities, with the possibility also of providing remote control of selected stimuli. Continuous measurement of physical conditions within the environmental chambers (ambient temperature, humidity, air ionization, barometric pressure, air velocity, light intensity, chemical composition of the air within the chambers, and other such physical parameters as may be shown to be significant) may be recorded along with the physiological activity specific to the animals. The behavior of the animal may be observed by a remote visual system. The construction and operating principles of the system are discussed. (Quoted in part)

319

**Dynamics of Changes in Carbon Dioxide Stores.** L. E. FARHI and H. RAHN.—*Anesthesiology*, 21 (6, Part I):604-614. Nov.-Dec. 1960.

Data for the CO<sub>2</sub> storage capacity and perfusion of various body systems and organs were collected and used to construct an electronic analogue computer considered suitable for determining the most critical physiological parameters in CO<sub>2</sub> retention or loss. The crucial point in CO<sub>2</sub> stores equilibration appears to be the effect of muscle perfusion on the functional storage capacity of the body. Since most of the CO<sub>2</sub> storage capacity resides in the muscle, perfusion of the muscle mass will determine the rate at which this storage capacity may be brought into play.

320

**Intermediate Glucose Metabolism in the Cold-Acclimatized Rat.** J. P. HANNON.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):100-105. Dec. 1960 (Part II).

The effects of 3-4 weeks' cold exposure (5° to -1° C.) on the activities of glucokinase, glucose-6-phosphatase, glucose-6-phosphate and 6-phosphogluconic dehydrogenases, total phosphorylase, phosphorylase a and b, phosphoglucomutase and pyruvate formation over the terminal glycolytic span of enzymes were assayed. Various shifts in the pattern of intermediary hexose metabolism as a result of cold exposure are discussed. (Author's abstract)

321

**Influence of Cerebral Activity in Wakefulness on Regulation of Breathing.** B. R. FINK.—*Jour. Applied Physiol.*, 16 (1):15-20. Jan. 1961.

Thirteen healthy men, unaware of the objectives of this study, underwent passive or active overventilation lowering the end-expiration carbon dioxide tension to 25 mm. Hg or below. At the end of the period of hyperventilation, rhythmic respiration con-

tinued uninterrupted at approximately the control frequency. The volume of ventilation was above control during the first minute of recovery and then stabilized at about two-thirds of the control volume; it continued at this level for over 10 minutes during which time the end-expiration PCO<sub>2</sub> gradually rose toward the control level. No instance of periodic breathing occurred. The absence of overventilatory apnea in the waking condition contrasts with its easy elicitation during general anesthesia. It is concluded that cerebral activity associated with wakefulness is a component of the normal respiratory drive, and that carbon dioxide acts by augmenting the effects of this component. (Author's abstract)

322

**Tissue Energy Metabolism in the Cold-Acclimatized Rat.** J. P. HANNON.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):139-144. Dec. 1960 (Part II).

Data are given relating the effect of duration of cold exposure on liver slice and whole-body oxygen consumption of laboratory rats. Data are also presented on the effect of cold exposure on various liver oxidase activities, oxidative phosphorylation and adenosine triphosphatase activities. The comparative study of electron transport components in liver and muscle is given. These data are discussed in relation to the development of non-shivering thermogenesis and the cellular metabolic control mechanisms in the cold-acclimatized animals. (Author's abstract) (33 references)

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**Adjustments of the Adrenal Cortex and Thyroid During Cold Acclimation.** O. HEROUX.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):82-85. Dec. 1960 (Part II).

An increased secretion of corticosteroids has been demonstrated by many authors in animals suddenly exposed to cold. In chronic exposure to cold in the laboratory, however, there is increasing evidence in the literature of a return towards the initial normal level in the activity of the adrenal cortex, while the thyroid remains hyperactive. Under the more natural fluctuating environmental conditions prevailing outdoors during the winter, the adrenal cortex of white rats exposed to cold for three months has been found to secrete *in vitro* at a faster rate than in the summer controls, while the thyroid appeared to be degenerating. In view of the metabolic effects of the thyroid and adrenal hormones, the endocrine adjustments observed under the two different environmental

conditions suggest different metabolic pathways leading to similar capacities for heat production. (Author's abstract)

324

**Primate Bio-Instrumentation for Two Jupiter Ballistic Flights.** W. C. HIXSON, C. T. PALUDAN and S. W. DOWNS.—*JRE Trans. Med. Electronics*, ME-7 (4):318-325. Oct. 1960.

A description is given of the bio-instrumentation phase of two related Army Jupiter ballistic missile flights involving squirrel monkey passengers, one of which was recovered alive and in good physical condition. These flights marked the initial entry into space, and successful return, of a primate under ballistic flight conditions comparable to those to be encountered by man. The paper describes the relationship of the instrumentation program to the biocapsule design in terms of the telemetered measurements. An outline is presented of the signal conditioning circuitry and associated transducers used for the in-flight telemetry recording of the primate's electrocardiogram, respiration rate, chest sounds, and axilla body temperature. Instrumentation related to the recording of the ambient temperature and pressure of the biocapsule, flash temperatures, and cosmic ray particle tracks is also described. (Authors' abstract)

325

**Metabolic Function of Ascorbic Acid in Acclimation to Cold.** D. J. HOIJER.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5): 90-93. Dec. 1960 (Part II).

The essential role of ascorbic acid in acclimation to cold has been affirmed by numerous experimental studies. The increased need for adrenaline and noradrenaline in the cold can be met in part by the ascorbic acid-stimulated hydroxylation of their aromatic precursors. Likewise, the hydroxylation of corticosteroids is stimulated by ascorbic acid to provide an adequate supply of the hormones necessary for increased substrate utilization and to combat the conditions of stress. Finally, the role of ascorbic acid in pathways of electron transport has been presented with reference to its possible function in effecting increased oxidation without concurrent increases in phosphorylation. (Author's abstract) (40 references)

326

**Acclimatization to Carbon Dioxide.** R. H. KELLOGG.—*Anesthesiology*, 21 (6, Part I):634-641. Nov.-Dec. 1960.

A review is presented of the adaptive changes which are produced and maintained as a result of deviations from the normal arterial  $\text{CO}_2$  tension which have

persisted for many days or longer. Emphasis is placed upon the alterations in the ventilatory response to  $\text{CO}_2$  and in the acid-base balance as they occur in normal subjects residing at high altitude who exhibit hypocapnia, and patients with pulmonary emphysema who exhibit hypercapnia. Consideration is given to (1) the relation of alveolar carbon dioxide to ventilation and metabolism; (2) acclimatization of the respiratory center to hypocapnia (including criteria for evaluation, carbon dioxide response curves at altitude, and genesis of altitude hypoxia); (3) acclimatization of the respiratory center to hypercapnia; (4) the time course of respiratory acclimatization to  $\text{CO}_2$ ; and (5) tissue changes in  $\text{CO}_2$  acclimatization. (41 references)

327

**Alterations in Hepatic Lipid Metabolism Induced by Acclimation to Low Environmental Temperatures.** E. J. MASORO.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):115-119. Dec. 1960 (Part II).

Two distinct kinds of information have been made available by experimentation on hepatic metabolism in the cold-acclimated rat. First, insight has been gained concerning the acclimation process as it occurs at the molecular level of organization; a mechanistic explanation has been presented for two important phenomena: (a) the great capacity of the cold-acclimated rat to resist fatty infiltration of the liver; (b) the ability of the cold-acclimated rat to maintain liver glycogen at surprisingly high levels during fasting. Second, the cold-acclimated animal has been shown to be a powerful tool for studying the physiologic regulators of intermediary metabolism. (Author's abstract)

328

**Effect of Body Posture on Lung Volumes.** F. MORENO and H. A. LYONS.—*Jour. Applied Physiol.*, 16 (1):27-29. Jan. 1961.

The changes produced by body posture on total lung capacity and its subdivisions have been reported for all positions except the prone position. Twenty normal subjects, twelve males and eight females, had determinations of total lung capacity in the three body positions, sitting, supine and prone. Tidal volume, minute ventilation and  $\text{O}_2$  consumption were also measured. The changes found on assumption of the supine position from the sitting position were similar to those previously reported. For the prone position, a smaller inspiratory capacity and a larger expiratory reserve volume were found. The mean values were changed, respectively,  $-8\%$  and  $+37\%$ . Associated with these changes was a significant increase of the functional residual capacity by 636 ml. Ventila-



tion did not change significantly from that found during sitting, unlike the findings associated with the supine position, in which position the tidal volume was decreased. Respiratory frequency remained the same for all positions. (Authors' abstract)

## 329

**Electrolytes in Acclimation to Cold.** W. S. PLATNER.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):130-131. Dec. 1960 (Part II).

The changes in the electrolyte content of tissues and serum of animals exposed to cold is discussed in terms of the effect of hormones upon the electrolyte balance. The independent variations of concentrations of ions under differing conditions of stress would indicate different mechanisms of control. Work by the author has shown that the magnesium content of serum and heart and muscle tissue increased 37% in rats exposed to 4.5° C. for 40 days. (Author's abstract)

## 330

**Adrenocortical Function in Rats Exposed to Low Environmental Temperatures.** E. SCHÖNBAUM.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):85-88. Dec. 1960 (Part II).

Measurements of corticosteroid formation *in vitro* can be used for the assessment of adrenocortical function in rats subjected to a variety of treatments. Acute exposure to cold causes a transient rise in adrenocortical activity during the first 30 minutes of exposure. If rats are kept in a cold environment for several weeks, an increased activity of the adrenal cortex is first observed but later the adrenocortical activity becomes somewhat reduced. (Author's abstract)

## 331

**Factors Which Affect Cold Acclimatization.** A. K. WEISS.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):137-138. Dec. 1960 (Part II).

Investigations of metabolic responses to cold exposure of various rat tissues and organs have shown that acclimatization to cold is best achieved by the relatively young rat (6-16 weeks old). The ability to achieve this acclimatization by metabolic means depends in part upon the availability of endocrine reserves. When these can be mustered they bring about an increase in heat production to balance the increased heat loss. In older or senescent rats where inadequate endocrine reserves prevent metabolic ac-

climatization to cold, the administration of thyroid compounds can bring about artificial acclimatization. (Author's abstract, modified)

## 332

**The Role of Carbon Dioxide in the Nervous System.** D. M. WOODBURY and R. KARLER.—*Anesthesiology*, 21 (6, Part I):686-703. Nov.-Dec. 1960.

It has been shown that various concentrations of CO<sub>2</sub> exert inhibitory and excitatory effects on the central nervous system (CNS). In addition, several drugs which mimic the effects of CO<sub>2</sub> on the CNS possess this activity by virtue of their ability to alter the tissue level of CO<sub>2</sub>. The mechanism of the CNS action of CO<sub>2</sub> appears dependent upon specific electrolyte and amino acid changes. These studies have also demonstrated that carbonic anhydrase is important in the regulation of the level of brain CO<sub>2</sub> and excitability and that the role of carbonic anhydrase in brain is ultimately concerned with the conversion of metabolically produced H<sub>2</sub>CO<sub>3</sub> to CO<sub>2</sub>. Furthermore, this functional role of the enzyme appears associated with the soluble fraction of the cell. (Authors' summary) (68 references)

## Physiology of Stresses

## 333

**On the Mechanism of Changes in the Permeability of Biological Barriers During Reduction of Atmospheric Pressure** (K mekhanizmu izmenenii pronitsaemosti biologicheskikh bar'erov pri snizhenii atmosfernogo davleniia.) Z. N. SHMIDT.—*Doklady Akademii nauk SSSR* (Moskva), 132 (5):1216-1218. June 11, 1960. In Russian.

The permeability of the blood-brain and blood-aqueous humor barriers was studied under the following conditions: (1) rapid ascent to 12 km. simulated altitude (19 rats), (2) rarified atmosphere of 145 mm. Hg, but with a partial pressure of oxygen between 101-123 mm. Hg (10 rats), and (3) gradual asphyxia in a sealed container with and without CO<sub>2</sub> removal (20 rats). The relative permeability for injected radioactive phosphorus was calculated from the amount of P<sup>32</sup> present in the brain and aqueous humor expressed as per cent of the amount of isotope in the blood serum (relative activity). The results indicate a significantly increased P<sup>32</sup> content in the brain and aqueous humor under condition (1); no increase under condition (2); and a reduction in P<sup>32</sup> content under condition (3). It is concluded that the shift in acid-base equilibrium (gaseous alkalosis) due to compensatory hyperventilation in hypoxia leads to increased transfer of the acid phosphate ion into the brain tissue and aqueous humor. Reduced barometric

pressure without hypoxia does not shift the acid-base equilibrium and the transfer of phosphate ions does not increase.

334

**Middle Ear Muscle Protection from the Acoustic Trauma of Loud Continuous Sound: An Electrophysiological Study in Cats.** F. B. SIMMONS. *Annals Otol. Rhinol. and Laryngol.*, 69 (4):1063-1071. Dec. 1960.

Serial measurements of cochlear microphonic and VIII nerve action potentials were obtained during exposure to traumatic sound (1 kc. for 2 hours at 135 db.) in cats with electrodes permanently implanted on their round windows. Exposed cats that were awake, and whose middle ear muscles were intact and active, showed considerably less evidence of trauma than did those with middle ear muscles deactivated by anesthesia or severed weeks before exposure. Action potential showed a greater depression than cochlear microphonic in all cats. It is concluded that the middle ear muscle reflex is capable of sustained protective action against traumatic sound. (Author's summary, modified)

335

**A New Method of Protection Against the Effects of Acceleration on the Cardiovascular System.** M. G. WEBB and R. F. GRAY. —*Amer. Jour. Cardiol.*, 6 (6):1070-1077. Dec. 1960.

A closed water-immersion system for the protection of the cardiovascular system of human centrifuge subjects against the effects of acceleration is described. One subject was exposed to accelerations as high as 31 g. The first subject had frontal sinus hemorrhage at 28 g, possibly due to high respiratory system pressure used to protect the chest but which was later found to be unnecessary. The second subject stopped at 26 g due to anxiety. The third subject successfully sustained a 31 g exposure for 5 seconds without injury. The only clearcut evidence of cardiovascular system dysfunction was frontal sinus hemorrhage. An additional advantage of the system was found to be that movement of the extremities during high accelerations was not hindered. (Authors' summary)

336

**The Influence of High Altitude on the Protein Composition of Human Blood** (O vliiani vysokogor'ia na belkovyi sostav krovi cheloveka.) E. P. SMOLICHEV.—*Biulleten' eksperimental'noi biologii i meditsiny* (Moskva), 50 (10):78-82. Oct. 1960. In Russian, with English summary (p. 82).

The blood protein composition was determined in 12 subjects in Stalinabad (850 m. above sea level)

and during four months stay on the East Pamir mountain (4200 m. above sea level). The total protein concentration increased during the first month at high altitude. Toward the end of the stay it receded, though still remaining above the initial level. The relative and the absolute albumin in blood serum dropped immediately after the ascent and remained low for a month after descent from 4200 m. to 850 m. The values for alpha-, beta-, and gamma-globulins rose immediately after ascent but returned to normal in the course of four months. In the first month after descent the alpha-, beta-, and gamma-globulin values were above the initial levels. The alpha<sub>2</sub>-globulin level increased upon descent. Oncotic pressure of the blood rose during the first month after ascent, then returned to normal at the expense of an increased concentration of the globulin fraction, which compensates for the decreased albumin content in blood serum. (Author's summary modified)

337

**Growth of Mouse Femurs During Continual Centrifugation.** C. C. WUNDER, S. R. BRINEY, M. KRAL and C. SKAUGSTAD.—*Nature* (London), 188 (4745):151-152. Oct. 8, 1960.

Five-week-old white mice first lost mass then continued to grow during exposure to continual centrifugation of 4 g for one to eight weeks. At the end of one week they had returned to approximately initial body mass. The femurs, however, continued to grow as fast as those of uncentrifuged litter mate controls in identical cages. At later developmental stages this rapid growth of experimental bones was less pronounced. The femurs of experimental animals also showed a more circular cross-section. Mechanical stress and moderate starvation are offered as possible explanations for the faster bone growth as compared to total experimental growth. The artificial increase in the force of weight during centrifugation could cause such a stress, and a lowered food consumption during the first week of centrifugation could be responsible for the initial decrease in body mass.

338

**Effect of Geographical Origin on Performance in Heat.** C. P. YAGLOU.—*Arch. Environmental Health*, 2 (1):1-8. Jan. 1961.

A comparison of the performance of young, southern Floridians with that of a similar group of New Englanders, walking in the humid heat of Homestead, Fla., indicated that the Southerners had a more efficient heat regulating system, which enabled them to perform the standard exercises with distinctly less sweating, and a smaller rise of body temperature and heart rate. The Southerners required a shorter period for physical conditioning in the heat, and lost ac-

climatization at a slower rate than the Northerners during periods of cool, rainy weather. The superior performance of the Southerners is ascribed to their long-term acclimatization, and their knowledge of living and working in their accustomed warm climate. It would seem that in selecting personnel for duty in hot areas, the geographical origin of the individual should be given a high priority, possibly next to that of physical fitness. (Author's summary)

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**Study on the Response of the Ophthalmic Artery Wave to Dynamic Action. I. Variations During Postural Alterations** (Rikigakuteki sayo ni taisuru gandomyaku myakuha no kenkyu. 1. Taii henkan ni yoru henka ni tsuite.) T. YAMAZAKI.—*Japanese Defense Forces Med. Jour.* (Tokyo), 7 (5):1-5. May 1960. In Japanese, with English abstract (p. 4-5).

Investigations were made of ophthalmic artery responses to changes in posture in an effort to gain insight into the possible effects that positive and negative accelerations may have upon cerebral blood circulation. With the subject lying on his back in a freely-tilting (up and down) bed, observations were made of variations in the curve of the ophthalmic artery wave during the following three positions: head-high (angle of tilt:  $+30^\circ$ ), horizontal, and head-low (angle of tilt:  $-30^\circ$ ). As the postural alterations proceeded from head-high to head-low positions, two types of curves were observed: one in which the first elevation remained as the highest peak, and the other in which the highest peak was maintained by a second elevation. Subjects exhibiting the two-peak type of curve showed a large variation in pulse pressure and some abnormalities in the circulation. (From the author's abstract)

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**Study on the Response of the Ophthalmic Artery Wave to Dynamic Action. III. Concerning Changes in Flight: Straight Climb and Level-Off** (Rikigakuteki sayo ni taisuru gandomyaku myakuha no kenkyu. 3. Hikochu ni okeru henka ni tsuite: chokusen joshu hiko reberuofu.) T. YAMAZAKI.—*Japanese Defense Forces Med. Jour.* (Tokyo), 7 (5):10-13. May 1960. In Japanese, with English abstract (p. 13).

The telemetrically-recorded ophthalmic artery waves of five students in flight were studied during postural change and during straight climb from 5,500 ft. to level-off at 6,000 ft. During straight climb, the pulse wave remained stable, whereas, at level-off, with the accompanying negative acceleration, fluctuations arose in the pulse wave curves. An appreciable recovery period was required for the curve to return to normal. It was observed that persons who showed the

two-peak type of curve during postural alterations also exhibited larger fluctuations of the curve during negative acceleration. (From the author's abstract)

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**Study on the Response of the Ophthalmic Artery Wave to Dynamic Action. IV. Concerning Changes in Flight: Climb Following Descent** (Rikigakuteki sayo ni taisuru gandomyaku myakuha no kenkyu. 4. Hikochu ni okeru henka ni tsuite: koka hikiokoshi joshu.) T. YAMAZAKI.—*Japanese Defense Forces Med. Jour.* (Tokyo), 7 (5):14-16. May 1960. In Japanese, with English abstract (p. 16).

The effects of negative and positive acceleration, generated by climb following descent, were studied on subjects exhibiting the two-peak type of ophthalmic artery wave curve during postural alterations. At the onset of negative acceleration, the curve was of large magnitude and its wave-length showed prolongation; at the onset of positive acceleration, the curve had a collapsed appearance and changes in its wave length were unrecognizable. It is stated that the ophthalmic artery wave curve is sensitive to alterations in flying posture, and reliable predictions may be made therefrom. Persons manifesting great changes in the pulse wave curve appear to have deficient blood pressure regulation; early detection of the two-peak type of curve through posture alteration tests may serve as a criterion for rejection. (Author's abstract, modified)

342

**Study on the Response of the Ophthalmic Artery Wave to Dynamic Action. II. On Recording the Ophthalmic Artery Wave Transmitted Over a Long Distance** (Rikigakuteki sayo ni taisuru gandomyaku myakuha no kenkyu. 2. Gandomyaku myakuha no entatsu kiroku ni tsuite.) T. YAMAZAKI.—*Japanese Defense Forces Med. Jour.* (Tokyo), 7 (5):6-9. May 1960. In Japanese, with English abstract (p. 9).

A device is described for recording the telemetered response of the ophthalmic artery wave to in-flight maneuvers. Graphic records are shown of responses during pre-flight (stand by), while climbing, and while turning during climb.

343

**Altitude Tolerance of Chickens and Pigeons.** P. D. ALTLAND.—*Jour. Applied Physiol.*, 16 (1): 141-143. Jan. 1961.

Chickens and pigeons were exposed for 6 hours to various simulated high altitudes to determine the highest altitude tolerated without deaths and the lowest altitude at which there are no survivors. Six- to seven-week-old chicks were less tolerant than twenty- to twenty-five-week-old chickens. All chicks survived ex-

posure to 12,000 feet, 90% survived 14- and 16,000 feet and, at higher altitudes, the survival was progressively lower until none survived at 26,000 feet. All older chickens survived exposure to 16,000 feet; approximately 88% survived altitudes up to 20,000 feet and, above this, survival was greatly decreased until none survived at 26,000 feet. Roosters showed a greater altitude tolerance than hens, a sex difference contrary to that found in mammals. Six- to ten-week-old pigeons survived 6-hour exposures to all altitudes including 28,000 feet and 97% survived exposure to 30,000 feet. Only 27% survived 32,000 feet and all died within 10 minutes at 34,000 feet. The results indicate that chickens have a much lower altitude tolerance than all other small warm-blooded animals previously studied. (Author's abstract)

## 344

**Transaminase Activity After Experimental Hypoxia in Rabbits.** J. E. ASVALL.—*Scandinavian Jour. Clinical and Lab. Invest.* (Oslo), 12 (2): 239-246. 1960. In English.

A significant increase (two and one-half times the pre-experimental value) of glutamic oxalacetic transaminase was found in the blood of rabbits exposed for one-half hour to 3.8 vol. per cent oxygen (transient hypoxia). The concentration returned to near normal about 20 hours after exposure in most rabbits. Determinations of transaminase in the blood and cerebrospinal fluid of other rabbits 20 minutes after hypoxia death (100 per cent nitrogen for 5-8 minutes) revealed a general tendency toward an increase over the pre-hypoxic levels. No significant difference in enzyme concentration was shown by comparing the animals killed by 5-8 minutes of hypoxia with those killed by other methods, but not exposed to hypoxia.

## 345

**Influence of Cold Exposure on Electrolyte Metabolism.** D. G. BAKER.—*Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: Federation Proceedings*, 19 (4, Supplement no. 5): 125-130. Dec. 1960 (Part II).

The influence of exposure to cold on electrolyte metabolism has been discussed under two headings: first, the early changes, and second, those responses which are elicited only with prolonged exposure. The early response is characterized by a hemoconcentration of brief duration, and, in man, a pronounced diuresis. The concentrations of plasma electrolytes remain relatively unaltered except for an increase in plasma potassium and probably magnesium. After prolonged exposure to cold there is a disappearance or even a reversal of the early changes. Body water and blood volume increase. The total water content of muscle is decreased while the chloride space is in-

creased. The concentrations of potassium and chloride in the plasma remain in the normal range while the sodium concentration is elevated. (Author's abstract) (45 references)

## 346

**Urinary Excretion of 3-Methoxy-4-Hydroxymandelic Acid After Several Stress Situations.** M. L. BERMAN and J. A. PETTITT.—*Jour. Lab. and Clinical Med.*, 57 (1):126-135. Jan. 1961.

Quantitative chromatographic analysis of 3-methoxy-4-hydroxymandelic acid, a major, chemically-stable urinary product of both adrenaline and noradrenaline in the normal human being, was determined in six healthy, experienced test pilots 1 and 3 hours after the following stress situations: forward acceleration, high altitude, heat, isolation, and a 4-hour period of psychologic tests. The urinary output of this metabolic product was significantly elevated only after the acceleration and altitude stress. Healthy human subjects exposed to a series of real and mock forward accelerations showed a significant elevation in the urinary excretion of 3-methoxy-4-hydroxymandelic acid after both a real and mock acceleration. The data suggest that in normal healthy subjects not exposed to a hazardous stress the urinary excretion of this metabolic product is relatively constant, but under certain specific stresses it is significantly elevated. (Authors' abstract)

## 347

**Plasma and Tissue Electrolyte Changes Produced in Dogs by Hypercapnia, Hypocapnia, and Hypoxia.** C. BIDDULPH, H. HOF, R. CLANCY and E. B. BROWN.—*Univ. of Minnesota Medical School, Department of Physiology, Minneapolis; issued by School of Aviation Medicine, Aerospace Medical Center, Brooks Air Force Base, Texas. Report no. 60-83, Sept. 1960. 6 p.*

Unclassified

Sodium, chloride, and potassium concentrations were determined on heart, liver, and skeletal muscle of dogs subjected to one of four procedures: one hour of controlled breathing at normal rate (controls), one hour of breathing 30 per cent CO<sub>2</sub> (hypercapnia), one hour of hyperventilation (hypocapnia), or one hour of breathing 8 per cent O<sub>2</sub> (hypoxia). In addition to Na, Cl, and K, bicarbonate was determined on skeletal muscle. Plasma values for these electrolytes and pH were determined. The usual picture of respiratory acidosis from breathing a high CO<sub>2</sub> mixture, respiratory alkalosis from hyperventilation, and mild respiratory alkalosis from hypoxia are apparent in the blood data. The only tissue electrolyte change sufficiently large and consistent to be potentially useful as a postmortem test for an abnormal premortem condition was the change in bicarbonate content of skeletal muscle. The use-

fulness of this test (for establishing the cause of air crashes otherwise unexplainable) is limited, however, by the fact that the concentration of bicarbonate in tissue changes with the time the tissue is exposed to air. (Authors' abstract)

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**Serum Glutamic Oxalacetic Transaminase Content in Hypothermia.** E. BLAIR, R. HOOK, H. TOLLEY and G. E. BUNCE. *Science* (Washington), 133 (3446): 105-106. Jan. 13, 1961.

When the body temperature of pentobarbitalized dogs was lowered by surface-immersion technique to 27°-26° C., elevations in serum glutamic oxalacetic transaminase were found only after a period of prolonged hypothermia (12 hours). When the animals were rewarmed, serum levels returned to normal. Histologic study of organs rich in glutamic oxalacetic transaminase revealed no necrosis. The cause for the elevations is not known, although increased membrane permeability secondary to prolonged cold may be a factor. (Authors' abstract)

349

**Relation of Ascorbic Acid to Adrenocortical Function During Cold Stress.** W. M. BOOKER. —Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5): 94-96. Dec. 1960 (Part II).

Either the fall in adrenal ascorbic acid in acute cold stress seems to be a "trigger" mechanism for the release of adrenocortical hormone, or ascorbic acid takes part in the formation of the adrenocortical hormone. In adrenal vein effluent the rise of ascorbic acid precedes by several minutes the rise of the adrenocortical hormone. There is no essential change in the whole-body ascorbic acid during cold stress. Ascorbic acid (a) acts to increase the survival of mice in cold, especially in the presence of either the adrenal gland or the administered cortisone; (b) decreases the rate of metabolism of the adrenocortical hormone in incubated liver slices; and (c) facilitates the conversion of C<sup>14</sup> acetate to cholesterol in the presence of ACTH. (Author's abstract)

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**Effects of Exposure to Cold on Coenzyme A Levels in Liver Tissue.** J. CAMPBELL, G. R. GREEN, E. SCHÖNBAUM and H. SOCOL. —Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5): 124-125. Dec. 1960 (Part II).

In rats exposed to cold for 24 days, a 60% increase occurs in the concentration and amount of coenzyme A in the liver. Also under these conditions the oxidation of fatty acids is accelerated, while the acetylating capacity of the rat is decreased. (Authors' abstract)

351

**Energy Requirements of Men in Extreme Heat.** C. F. CONSOLAZIO, R. SHAPIRO, J. E. MASTERSON and P. S. L. MCKINZIE. —*Jour. Nutrition*, 73 (2):126-134. Feb. 1961.

The effects of solar radiation and extreme heat on the energy requirements of eight healthy young men performing a constant daily activity were studied under the following conditions: (1) ten days in direct sunlight from 7 A.M. to 5 P.M., with temperatures averaging 40.5° C.; (2) ten days in the hot shade from 7 A.M. to 5 P.M., with temperatures averaging 40.3° C.; and (3) ten days in an air-conditioned room at 26.0° C. The data suggest that there is an increased caloric requirement for men working and living in extreme heat. Significant increases were observed in food consumption and the actual caloric requirements were even greater because of changes in the body composition of the men. The differences in energy cost of the various resting and exercise activities, when comparing the hot-sun or hot-shade to the cool-shade phase were significant. Energy requirements averaged 55.5, 56.4, and 36.6 Cal. per kg. of body weight, respectively, for conditions (1), (2), and (3), when corrected for body composition changes. These increased requirements are probably due to the increased heat load imposed on the body by solar radiation and extreme heat. The increased requirements are, in all likelihood, a combination of increased action of the blood in heat transport, increased action of the sweat glands, plus the increased total metabolic rate due to the elevation in body temperature. (From the authors' summary and conclusions)

352

**Exposure to Cold and Catecholamines.** U. S. VON EULER. —Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5): 79-81. Dec. 1960 (Part II).

Estimations of the chromaffin reaction in the adrenal gland of animals exposed to cold have shown that when the cold stress was moderate and the animals remained in a good state over a prolonged period, a more or less normal picture was observed in the adrenal medulla. Likewise, in cold-adapted animals the catecholamine content in the gland may be normal or even increased. From these observations it is hard to draw conclusions as to the actual release. On the other hand acute cooling, accompanied by a fall of body temperature of several degrees C., is followed by a definite increase in the release of adrenaline and also by its depletion in adrenal glands. The importance of following continuously the catecholamine produc-

tion over prolonged periods of cold stress and adaptation by measuring the output in urine is emphasized. (Author's abstract)

## 353

**Coronary Lipid Deposition During Chronic Anemia or High Altitude Exposure.** L. C. FILLIOS, S. B. ANDRUS and C. NARRO.—*Jour. Applied Physiol.*, 16 (1):103-106. Jan. 1961.

Experimental anemia and polycythemia were studied in hypercholesteremic rats. The following results were noted: (a) chronic anemia favors a significant increase in endocardial and coronary lipid deposition; (b) rats made polycythemic by prolonged exposure to simulated high altitudes also had a marked degree of coronary involvement but no apparent increase in endocardial sudanophilia; (c) sea-level cobalt polycythemia does not appear to favor an increase in coronary or endocardial sudanophilia, suggesting that (d) polycythemia, per se, does not favor an increase in lipid deposition at these sites. These findings suggest that tissue hypoxia may account for the above increases in coronary sudanophilia, while changes in endocardial sudanophilia appear to be related more closely to the circulating cholesterol for all the groups. (Authors' abstract)

## 354

**Effect of Hypothyroidism on Heat Production and Loss During Acute Exposure to Cold.** M. J. FREGLY, P. F. IAMPINETRO and A. B. OTIS.—*Jour. Applied Physiol.*, 16 (1):127-132. Jan. 1961.

Thyroidectomy (propylthiouracil treatment) and adrenalectomy increased the rate of cooling of rats restrained and subjected to air at 5° C. At the same colonic temperature during cooling, both thyroidectomized and adrenalectomized rats maintained higher skin temperatures than control rats. Heat production (measured by oxygen consumption) was determined for thyroidectomized and control rats only. At the same colonic temperatures during cooling, thyroidectomized rats had the same heat production as controls. However, heat loss at a given colonic temperature during cooling was greater for thyroidectomized than for control rats. The inability of thyroidectomized rats to tolerate cold as well as control rats under these conditions was almost entirely due to a more rapid loss of body heat. The cause of failure of heat conservation may be related to changes in vascular reactivity induced by the hypothyroid state. (Authors' abstract)

## 355

**A Unified System for Evaluation and Selection of Heat Stress Candidates.** J. GOLD.—*Jour. Applied Physiol.*, 16 (1):144-152. Jan. 1961.

A system for the evaluation and selection of heat stress candidates has been developed that is con-

cerned not only with the extent to which an individual is capable of dissipating heat, but also the price he must pay for so doing. The former is dealt with through the concept of effective body heat storage ( $q_e$ ); the latter, through a newly developed index of strain ( $I_G$ ). Effective body heat storage is defined as that amount of storage obtained if a subject were able to go into a heat chamber already fully equilibrated with it and with all heat-dissipating mechanisms fully operating. The index attempts to express a new concept, accumulative circulatory strain, in terms of heart rate alone. The best subjects (usually in the young age groups) show a low  $q_e$  and low  $I_G$ ; the worst (usually in the older age groups) show a high  $q_e$  and low  $I_G$ . All subjects were maintained at rest during heat exposure. (Author's abstract)

## 356

**Energy Metabolism During Exposure to Cold.**

J. S. HART.—Proceedings of the International Symposium on Cold Acclimation, Buenos Aires, August 5-7, 1959. Published in: *Federation Proceedings*, 19 (4, Supplement no. 5):15-19. Dec. 1960 (Part II).

Exposure of small mammals and birds to constant cold which results in chronic elevation of energy metabolism leads to well-defined alterations in metabolic processes. The most important of these is the development of an enhanced capability to elevate metabolism and maintain it at a high level and by this means to prolong survival at low lethal temperatures. Other associated changes include a gradual disappearance of shivering, an increase in peripheral temperatures (rats), and a decrease in body insulation (most species). Rats and deer mice exposed outdoors during summer and winter also have comparable changes in cold resistance and metabolic capability but differ in having increased pelage insulation (rats and mice) and lower peripheral temperatures (rats) during the cold season. It is concluded that seasonal and temperature-induced changes are not identical in these animals. (Author's abstract)

## 357

**A Criterion for Evaluation of Noise Exposure.**

ALLEN R. JONES and F. W. CHURCH.—*Indus. Hygiene Jour.*, 21 (6):481-485. Dec. 1960.

A new method of appraising noise exposures has been developed. It is based on the concept of hearing conservation rather than of damage risk. Hearing conservation criteria are used to judge whether or not hearing conservation measures should be taken rather than to predict when hearing loss will occur. The method proposed for evaluating noise data takes into account the more restrictive recommendations made recently for the 4th, 5th and 6th octave bands. Exposure time variations are taken into account by means of a new form that has been devised for plotting octave band measurements. A supplemental graph is presented

and can be used for summing up noise exposures at different intensity levels, with the over-all exposure expressed as "Per cent of Allowable Weekly Noise Dose." (Authors' summary)

358

**The Noise Problem.** T. C. JONES.—*Tactical Air Command Surgeon's Bulletin*, Headquarters Tactical Air Command, Langley Air Force Base, Va., 1 (2): 2-8. May 1960.

The sources of noise on some Air Force bases are: (1) aircraft undergoing maintenance run-ups; (2) aircraft and missiles during take-off or flight; (3) engine test stands; (4) rocket and missile test firings; (5) various ground power units or static machinery, such as sheet metal or carpenter shops; and (6) traffic and people. These sources may cause physical injury to man (deafness), interfere with communications, cause fear and annoyance, and induce or contribute to accidents.

## Neuro- and Sensory Physiology

359

**Some Determinants of Two-Dimensional Visual Tracking Behavior.** J. A. ADAMS and L. V. XHIGNESSE.—*Jour. Exper. Psychol.*, 60 (6):391-403. Dec. 1960.

A two-dimensional discrete pursuit tracking apparatus with two visual stimulus sources and a control stick for each hand was used to investigate two values each of stimulus coherency, spatial separation of stimulus sources, and the rate of change of events. The findings revealed that tracking proficiency was related positively to the proximity of stimulus sources and inversely to the speed of event change when stimulus coherency was low. When coherency was high, only event rate was a differentiating variable. Spatial separation did not distinguish between the groups of any given rate condition, presumably because the subject was utilizing his capability for predicting high-coherency events to reduce the demands of visual scanning when stimulus sources were widely separated. The results are discussed in terms of hypotheses for prediction behavior in visual-motor responding. (From the authors' summary)

360

**The Perception of Moving Objects. I. Ability and Visual Acuity.** W. A. CRAWFORD.—*RAF Inst. of Aviation Medicine* (Gt. Brit.), Farnborough; issued by Flying Personnel Research Committee (Gt. Brit.). FPRC Memo no. 150a, July 1960. 10 p.

Unclassified

Six factors were examined in relation to the ability to perceive the detail in moving targets: (1) the basic

ability of subjects with randomized target velocities, (2) the relationship of discrimination to latency of eye movement, (3) the effect of increasing viewing time, (4) the effect of coordinated head and eye movements, (5) the effect on ability when the target image first appeared on different areas of the retina, and (6) the effect of training. Ability is related not only to object size and brightness and state of training, but also to the time available for viewing, the coordinated activity of the head and eyes, and the area of the retina which is initially stimulated. (Author's summary, modified)

361

**The Perception of Moving Objects. II. Eye Movements.** W. A. CRAWFORD.—*RAF Inst. of Aviation Med.* (Gt. Brit.), Farnborough; issued by Flying Personnel Research Committee (Gt. Brit.). FPRC Memo no. 150b, July 1960. 24 p.

Unclassified

Eye movements (recorded during experiments on ability to perceive detail in moving targets) were of two types, one containing a second saccade which is assumed to be of corrective nature, the other showing a smooth eye movement. The latency of eye movements varied from 150-300 milli-sec., having a mean of some 200 msec. The incidence of second saccades with target angular velocities of 50°/sec. or more was 50-100%. There was some diminution in incidence at 125°/sec. which indicated a commencing total failure of the oculomotor system. The intersaccadic intervals recorded were often less than 120 msec. which is the minimum period recorded by investigators of eye movements. The steady state period may be as short as 50-70 msec. This is the period during which a corrective eye movement is assumed to be organized and executed. This short period is not compatible with current concepts of the times involved in the oculomotor system. Some potential and alternative system schemes are discussed. (Author's summary, modified)

362

**Visual Acuity and Moving Objects. III. The Coordination of Eye and Head Movements.**

W. A. CRAWFORD. *RAF Inst. of Aviation Med.* (Gt. Brit.), Farnborough; issued by Flying Personnel Research Committee (Gt. Brit.). FPRC Memo no. 150c, July 1960. 9 p.

Some physiological actions underlying the improvement in the perception of detail in moving targets when the head and eyes were free to move were investigated. The coordinated head and eye movements resulted in a less sustained deviation of the eyes from their resting position. The initial saccadic eye movement is unchanged from the "eyes alone" situation but

thereafter the head develops a velocity which markedly reduces the need for gross rotations of the eyes. The angular velocity of the head is comparable to the target velocity and lags behind the target by some  $5^{\circ}$ - $20^{\circ}$  of arc, the faster the target the greater the lag in relative position. Head movement latency is about 100 millisecon. greater than eye movement latency. The head movements are smooth and show no saccades. Electromyographic responses from neck muscles involved in eye-head movement showed activity before every movement commenced. (Author's summary, modified)

363

**Experimental Research on the Behavior of Vestibular Function After the Administration of Some Drugs. I. A Phenothiazine Derivative** (Ricerche sperimentale sul comportamento della funzione vestibolare dopo somministrazione di alcuni farmaci. I. Un derivato della fenotiazina). F. CHINELLATO.—*Bolletino della Società italiana di biologia sperimentale* (Napoli), 36 (18): 931-932. Sept. 30, 1960. In Italian

Post-rotatory nystagmus was induced in human subjects and guinea pigs subjected to a negative acceleratory stimulus of  $120^{\circ}$ /sec./sec. The oral administration of Torecan GS95 (a phenothiazine derivative) to these subjects under the same acceleratory conditions produced no change in post-rotatory nystagmus in the animals, but brought about a reduction or an inhibition of the reaction in man. It is postulated that Torecan GS95 has a selective action on the reticular substance (involved in vestibular and neurovegetative reflexes) of man.

364

**Role of Eye and Neck Proprioceptive Mechanisms in Body Orientation and Motor Coordination.** L. A. COHEN.—*Jour. Neurophysiol.*, 24 (1):1-11. Jan. 1961.

Proprioceptive mechanisms in the extraocular muscles, ciliary muscles of accommodation, and the first three cervical vertebrae of monkeys and baboons were abolished singly and in combination, and the resultant effects on orientation of the organism and motor coordination were studied in a specially designed testing room. None of the animals in which all of the extraocular muscles of the right eye were detached showed any observable defect in either balance, orientation, or motor coordination. The most common finding for animals with ciliary muscles paralyzed with atropine or homatropine was a general inactivity and a slow and methodical type of activity when they did move. The results were the same whether homatropine was applied (1) only to the intact eye of an animal with detached extraocular muscles of the other eye, (2) to both operated and unoperated eye, or (3) to both eyes of normal animals in which no extraocular muscles

were detached. Animals subjected to bilateral anesthetic block of the dorsal roots of the first three cervical vertebrae suffered severe defects in balance, orientation, and motor coordination. These manifestations were similar to the defects described in labyrinthectomized animals. The results suggest that the vestibular organs are essential for orienting the head in space and that the neck proprioceptors are equally essential for orienting the head in relation to the body.

365

**Sensory Deprivation and Pain Thresholds.** J. VERNON and T. E. MCGILL.—*Science* (Washington), 133 (3449):330-331. Feb. 3, 1961.

The confinement of nine adult male subjects for four days in a light-proof, soundproof cubicle resulted in a lowering (average of 0.108 milliamperes) of their thresholds for electrically induced pain. Nine control subjects (not exposed to any sensory deprivation) showed an insignificant average drop of 0.019 ma. after four days spent in normal activity. The effect of the reduction in sensory input on the action of the reticular formation of the brain stem is discussed.

### Medical Problems Including Toxicology and Pharmacology

366

**Space Medicine.** J. HORAK.—*South African Med. Jour.* (Cape Town), 34 (53): 1117-1122. Dec. 31, 1960.

Current space travel may be classified as being in a phase of global space-equivalent flight, as defined by the combined factors of the physiological and mechanical properties of the space environment, the speeds attained in space flight, and the distances rockets travel over and away from the earth. The attendant medical problems are basically those of high altitude flight as we know it today, and most of the problems involved in true space flight are encountered in the stage of global space-equivalent flight.

367

**Aeromedical Evacuation.** S. JAYANGANANDA.—*Royal Thai Air Force Med. Gaz.* (Bangkok), 9 (1): 45-62. Feb. 1960. In Thai.

A general discussion is presented on the selection of patients for air travel, and on their care and treatment by medical personnel during flight. Special consideration is given to the air transport of surgical patients, those with cranial injuries, and patients suffering from gastrointestinal, cardiovascular, thoracic, pulmonary, ocular, and respiratory diseases. Mention is made of the problems encountered during flight which may affect these patients, such as decreased atmospheric pressure and temperature, hypoxia, hyperventilation, and airsickness.



368

**Otolaryngology.** F. L. LEDERER and B. J. SOBOROFF.  
—In: *Cyclopedia of medicine, surgery, and specialties: Review service*, 1960, p. 507-515. Ed. by G. M. Piersol and E. L. Bortz. Philadelphia: F. A. Davis Company, 1960.

Various pathological conditions of the ear and larynx are reviewed. A brief discussion is given of the etiology, prognosis, and treatment of sinus barotrauma, a condition which is becoming more prevalent as travel by air increases.

369

**Pathogenesis and Clinical Picture of Vibrational Cochleovestibular Disorders** (Pato-genez i klinika vibratsionnykh kokhleovestibul-arnykh narushenii). IA. S. TEMKIN.—*Vestnik oto-rino-laringologii* (Moskva), 22 (3):5-15. May-June 1960. In Russian, with English summary. (p. 15.)

Disturbances of the cochleovestibular function are relatively frequent in workers in reinforced concrete plants. Sound and vibration play an important role in the pathogenesis of hearing disorders, causing a reduced perception of both high and low sounds. A complete or partial disappearance of the rapid component of experimental nystagmus is the objective symptom of the central lesion. Sometimes it is one of the earliest symptoms of vibration disease. (Author's summary, modified)

370

**Preventive Medicine Aspects of Air Travel.**

C. A. TINSMAN.—*Pennsylvania Med. Jour.*, 64 (1): 63-67. Jan. 1961.

The physical conditions or illnesses which determine who should travel by air, and some of the public health ramifications of such methods of travel are discussed. Generally, air travel limitations are imposed by such conditions as heart diseases, severe respiratory disturbances, severe anemia, and gas confined in body cavities, conditions that are most easily affected by changes in altitude and barometric pressure. Other contraindications include sickle cell anemia, acute stages of infectious diseases, a moribund state, wired jaws, acute alcoholism and psychoses without sedation or restraint. Other aspects of aviation discussed as being within the realm of preventive medicine are: air rescue and evacuation of the wounded; transport of drugs, sera, and antidotes by aircraft; the rapid dissemination of communicable or exotic diseases; the selection and physical maintenance of aircrews; and the human engineering aspects of air frame manufacture (spacing and facing of seats, the amount of pressurization, the availability of oxygen, the arrangement and lighting of the cockpit, and the noise level). The improvements which are realized in all phases of

air safety are cited as contributions of preventive medicine. The medical problems and preventive medicine aspects of space travel are briefly defined as being extensions of the problems of air travel, with shifts in emphasis on specific problems.

## Personnel

371

**Some Aspects of Physiology Training in Naval Aviation.** J. P. POLLARD.—*Military Med.*, 126 (2): 133-139. Feb. 1961.

The development of training in high altitude physiology in naval aviation is briefly traced from its beginning prior to World War II until 1 July 1960. This includes a record of its extensive growth during World War II, subsequent collapse during the period of postwar demobilization, and slow but steady regrowth to its present form. The introduction of generations of progressively higher performance aircraft in the postwar years necessitated revitalization of this training program and modification of its content to serve operational needs. Extension of the training is shown into such related fields as the use of full pressure suits and other personal equipment items which are transitional in nature leading into physiological training for orbital and space flight. (Author's summary)

## Survival and Rescue Including Nutrition

372

**Lunar Life Support Systems.** J. G. GAUME.—*Missile Design and Development*, 7 (1): 46-48, 52, 54. Jan. 1961.

The objectives and duration of a particular mission will determine the type of life support system which man will utilize on trips into space. On short trips to the moon and back, stored oxygen, food, water, chemicals for absorption of CO<sub>2</sub>, odors, and other noxious gases will be carried in sufficient quantities to last the duration of the mission. Stored food and physico-chemical methods of recovering oxygen and water will suffice for short visits on the moon or another planet. A closed ecological system that theoretically could be used indefinitely will be required for the lunar base or orbital space station. Such a system would regenerate and purify its own atmosphere, produce its own food, and re-utilize all its own wastes in producing food. Brief discussions are given on the suitability of algae for atmosphere regeneration, hydroponic techniques and animal colony maintenance for food production, and various methods for re-cycling wastes into the system.

## Operational and Human Engineering Aspects

373

**A Comparative Evaluation of a Pursuit Moving-Airplane Steering Display.** D. K. BAUER-SCHMIDT and S. N. ROSCOE.—*JRE Trans. on Human Factors in Electronics*, HFE-1 (2):62-66. Sept. 1960.

An experiment was conducted using a flight simulator to determine the relative ease with which pilots can learn to use four types of airborne fire-control system steering displays. The four displays compared were (1) a moving-horizon display with a space-stabilized error dot, (2) a moving-horizon display with an aircraft-stabilized error dot, (3) a compensatory type moving-airplane display, and (4) a pursuit type moving-airplane display. Of the four displays, the moving-airplane types were found to yield significantly smaller firing errors and require less learning as compared to either moving-horizon type display. Furthermore, the pursuit type of moving-airplane display yielded learning performance and terminal performance error levels superior to any of the other displays. (Authors' summary)

374

**Comparison of Tracking Performance in the TV-2 Aircraft and the ACL Computer/AMAL Human Centrifuge Simulation of This Aircraft.** JOHN L. BROWN, H. KUEHNEL, F. T. NICHOLSON and A. FUTTERWEIT.—Naval Air Development Center. Aviation Medical Acceleration Lab., Johnsville, Pa. Report no. NADC-MA-6016/NADC-AC-6008, Nov. 7, 1960. iv+166p. (Task no. MR005.15-1003.1, Report no. 4). Unclassified

A tracking task was performed by each of six subjects in a TV-2 aircraft, in a static simulation of the aircraft and in each of two centrifuge modes of simulation which provided acceleration forces similar to those encountered in the aircraft. Centrifuge accelerations were controlled by pilot performance in the simulation. In the case of four subjects who are qualified pilots, performance in the aircraft was consistently superior to performance on the centrifuge and frequently superior to performance under static conditions. The subject, a nonpilot, who had the best performance on the centrifuge, had the poorest performance in the aircraft. In a questionnaire, all subjects rated the aircraft best in terms of control response and tended to favor the aircraft over any of the simulations. Subjects reported that accelerations on the centrifuge were realistic as compared to accelerations in the aircraft under steady state conditions, but that they seemed somewhat unrealistic during rapid transitions from one acceleration level to another. It is concluded that the centrifuge is best suited for the

simulation of long duration, high magnitude accelerations of the kind which will be encountered in space vehicles such as the X-15 and the Mercury capsules. (From the authors' abstract)

375

**A Systems Analysis of Fast Manned Flights to Venus and Mars. I. Mission Philosophy, Life Support, Scientific Reconnaissance, and Prototype Vehicle Layout.** K. A. EHRLICH.—*Jour. Eng. for Industry*, 83, Series B (1):1-12. Feb. 1961.

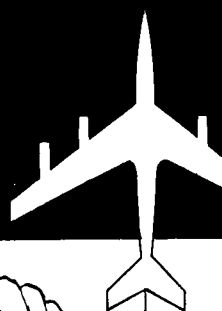
Suitable mission profiles to Venus and Mars are presented. Crew sizes between 12 and sixteen persons were found adequate for fast reconnaissance missions lasting about 1.5 and 1 year, respectively, for the two planets. The requirements for the ecological payload and the supporting systems are discussed, and the resulting weight requirements for the life support system and the scientific payload are determined. The ecological system contains the direct life-sustaining items (food, water, oxygen, and the absorber systems for odors and water) and the related mechanical systems required to contain and operate these items. The supporting system comprises the hull of the living space, furniture, and other equipment or installations, air locks, astrodomes, space suits, and taxicapsules (small one-man capsules for commuting between interorbital space craft).

376

**Determination of Human Operator Functions in a Manned Space Vehicle.** C. O. HOPKINS.—*JRE Trans. on Human Factors in Electronics*, HFE-1 (2):45-55. Sept. 1960.

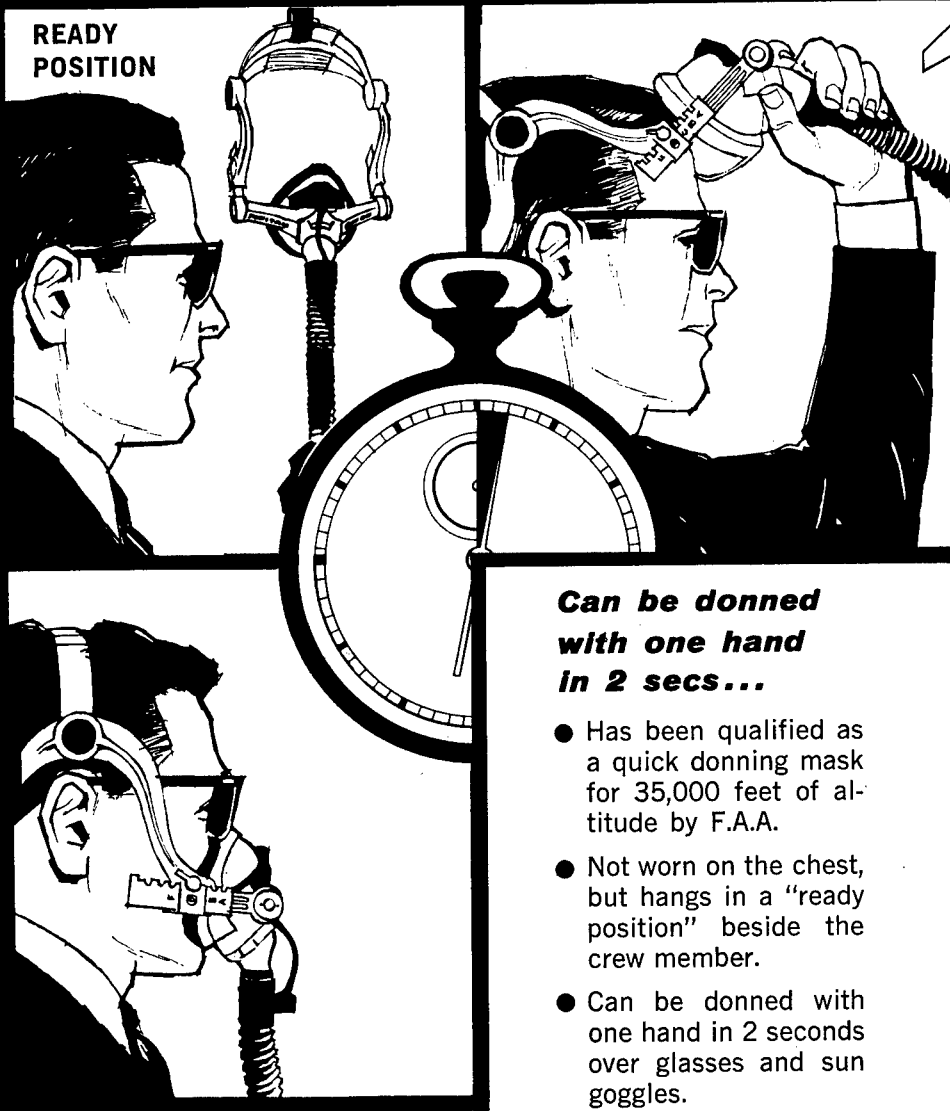
A practical methodology is described for determining the human operator functions within the context of a space mission. Using a space ferry mission (involving travel in both directions between the earth and a satellite orbiting the earth) as an example, it is indicated that the human operator may be profitably used in the performance of the following general classes of functions: (1) selection from among several sensing devices of the one to be used for providing control information, (2) manual operation of certain sensing devices, (3) transmitting to the system information acquired from auxiliary sensing devices, (4) limited processing of data from sensors by means of tables, graphs, and perhaps a manually-operated calculating machine, (5) manual control of vehicle attitude and main propulsion system in certain modes of system operation, (6) evaluation of the state of system in the light of planned mission requirements and the occurrence of unfavorable events, and (7) designation, and in some cases, execution of alternate basic system programs as a result of the evaluation of the state of the system. (From the author's summary)

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## International Congress of Aeronautical and Space Medicine

Professor R. Grandpierre, President of the 10th European Congress, has announced that the Congress will be held in Paris, France, September 26-30, 1961. Special topics for consideration will include: (1) Psycho-physiological problems resulting from adaptation or lack of adaptation to a space environment, (2) Patho-physiological problems attending flight in modern aircraft, (3) Recent physiological investigations in the field of space medicine, (4) Pathological problems of non-flying personnel responsible for flying safety.

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REFERENCES: 1. Marcus, P.S., and Sheehan, J.C.: *Anesthesiol.* 16:423 (May) 1955. 2. Bonica, J.J., Crepps, W., Monk, B., and Bennett, B.: *West. J. Surg.* 67:332 (Nov.-Dec.) 1959.



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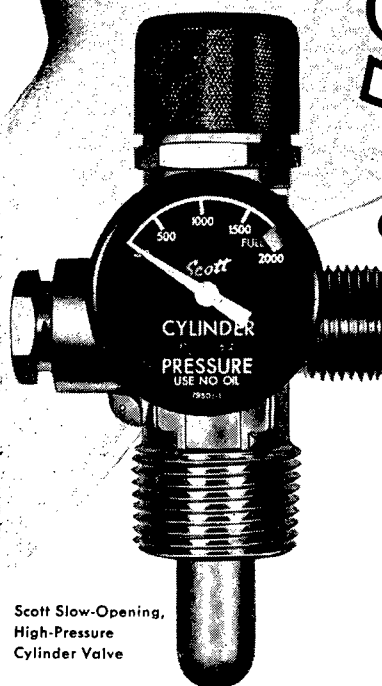
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